VOLUME IV

POTENTIOMETER TEST REPORT

SUPPLEMENT TO

QUALIFICATION TEST REPORT

FOR

MOOG MODEL 17-150D SERVOACTUATOR

AND

MOOG MODEL 16-120A SERVOVALVE

Moog Servocontrols, Inc.
East Aurora, New York

Report No. MR 838
Revision "A"

PRONER AIRPORT, EAST AURORA, N. Y.

FROM MOOG

SERVOCONTROLS, INC.

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Date: September 24, 1964

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TABLE OF CONTENTS

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES

1.0 INTRODUCTION

Volumes I to III of MR 838 document the qualification tests of Moog Model 17-150D servoactuator and Moog Model 16-120A servovalve which were performed during the period of July 16, 1963, to January 17, 1964. This Volume IV of MR 838 documents a supplemental program of environmental tests on the Markite Model 9044 potentiometer, a redesigned version of the Model 8520 potentiometer, which had proved unqualifiable in the original program. The tests reported herein were conducted during June and July of 1964. The object of the supplemental program was to qualify the Markite Model 9044 potentiometer which will be employed in Moog Model 17-150E servoactuators.

Authorization for the extension of the qualification program to include the subject potentiometer tests was provided by Modification number 5 to NASA contract number NAS 8-2674.

2.0 BACKGROUND

Background information concerning the potentiometer failures which occurred in the original program and which led to redesign and retest is fully detailed in Volume I, sections 7.1, 7.12, and Volume III, Appendix A. In brief, these failures were:

a. Degradation of element linearity to out-of-tolerance condition during the program.

b. Loss of circuit continuity due to high temperature environmental exposure.

In addition, NASA had experienced several instances of potentiometer linearity degradation to an out-of-tolerance condition on spare potentiometer units while in storage.

Moog conducted a comprehensive failure analysis of the continuity failure identifying the design faults and recommending certain design modifications (reference Appendix A, Volume III). With regard to the linearity discrepancies, Markite recognized a sensitivity of the resistive elements linearity to humidity conditions and suggested the incorporation of recent advances in their resistive plastic technology (proprietary).

At a design review meeting of NASA, Markite, and Moog representatives on February 26, 1964, it was agreed to incorporate the Moog and Markite recommendations for redesign of the potentiometer. Subsequent negotiations between NASA and Moog established the additional tests required to qualify the new design, as reported herein.

Markite also agreed to conduct comparative environmental tests of the type 8520 and type 9044 resistive elements to demonstrate that the new design would have better linearity stability. The results of these tests were subsequently documented in Markite Engineering Report No. 664, dated May 20, 1964. The report concludes that the type 9044 potentiometer will offer greater shelf life linearity stability than the type 8520 potentiometer, however, it must be stated that the evidence presented does not wholly support that conclusion. Sensitivity to humidity was shown to be considerably improved in 5 type 9044 elements compared to one type 8520 element, however, two out of four type 9044 elements tested evidenced greater sensitivity to high ambient temperature soak than did the two 8520 elements tested. It should be noted that the high temperature soak was for 10 days at 120° C (+248° F), which is far in excess of the specified storage conditions.

3.0 SUMMARY OF RESULTS

The performance characteristics of the basic potentiometer (exclusive of the electrical connector assembly) were satisfactory throughout the supplemental potentiometer test program except for the following minor discrepancies:

a. One element of one specimen exceeded the contact resistance noise limit during two performance tests, one of which was initial performance (reference section 7.1).

b. A deviation from the linearity tolerance was observed at one point on one potentiometer element. The performance was satisfactory during Trial I but shifted slightly to an out-of-tolerance condition during Trial II.

Linearity stability of the Model 9044 specimens was definitely better than that evidenced by the Model 8520 specimens during the servo-actuator test program. Evidently the change in resistive plastic material was beneficial in this respect.

Evaluation of the electrical connector/printed circuit/junction box assembly was obviated for the first sequence of tests (Trial I) because Markite omitted the silastic potting of the junction box cavity. This resulted in a post-humidity insulation resistance breakdown of the stycast potting material surrounding the electrical connector/printed circuit junction.

Omission of the silastic potting process was due to an unclear note on Markites' assembly drawing, which has since been corrected. Also, the stycast potting surface will be coated with insulating varnish for additional protection from humidity.

After rework of one specimen to incorporate the above processes a repeat of the environmental tests, designated Trial II, was conducted. These tests produced satisfactory results with respect to the electrical connector/junction box assembly.

Except for the minor discrepancy in contact resistance noise, the results of this test program show that the potentiometer design has been improved to a sufficient extent to satisfy qualification test requirements.

4.0 TEST SPECIMENS

Two Markite potentiometers, Model 9044, S/N 3MG010AR and S/N 3U654AR, manufactured by the Markite Corporation, 155 Waverly Place, New York, 14, New York (Moog P/N 062-42282).

5.0 TEST PROGRAM CHRONOLOGY

Test		S/N 3MG010AR	S/N 3U654AR
Initial Performance	Trial I	6/17/64	6/17/64
0°F Soak and Operation		6/18/64	6/18/64
Performance Test		6/19/64	6/19/64
275°F Soak and Operation		6/22/64	6/22/64
Performance Test		6/23/64	6/23/64
Humidity Test		6/26/64	6/26/64
		7/6/64	7/6/64
Performance Test		7/6/64	7/6/64
Units Sent to Vendor for Rework		7/8/64	7/8/64
Post Rework Performance Test		7/13/64	7/10/64
Unit Returned to Vendor for Rework		7/14/64	7/10/64
Post Rework Performance Test	Trial II	7/20/64	7/10/64
Humidity Test			7/15/64
			7/25/64
Performance Test			7/27/64
0°F Soak and Operation			7/27/64
Performance Test			7/28/64
275°F Soak and Operation			7/28/64
Final Performance Test			7/29/64

6.0 TEST PROCEDURES

6.1 Performance Tests

All performance tests were standard receiving inspection tests conducted by the Moog Inspection Department. Reliability Engineering conducted an additional test to measure the distance between the top of the connector pins and the connector rim for the initial and final performance tests.

6.2 Environmental Tests

6.2.1 0°F Soak and Operation

a. Place both specimens in the temperature chamber, with wipers slightly displaced from center. Run the electrical leads to the exterior of the chamber. Install an ambient thermocouple and a thermocouple on the potentiometer body.

b. Measure resistances between pins A-C. E-G, B-D, and F-H.

c. Measure and record the distance between pin tips and the connector rim.

d. Stabilize units and ambient at 0 ± 5°F.

e. Measure resistances as in (b) above at 0°F.

f. Hold ambient temperature at 0°F for eight (8) hours.

g. After eight hours measure resistances at 0°F as in (b) above.

h. Stabilize at room temperature and measure resistances.

i. Measure pin heights as in (c) above.

j. Return units to Receiving Inspection for performance tests.

6.2.2 275°F Soak and Operation

a. Place both potentiometers in the temperature chamber and bring the electrical leads to the exterior of the chamber. Install thermocouples to measure the potentiometer case temperature and ambient temperature.

b. Measure the connector pin heights as in 6.2.1c above, at ambient temperature.

c. Record pin-to-pin resistance measurements as in paragraph 6.2.1b.

d. Energize the potentiometer per Figure 17 of the Qualification Test Procedure, MR 725. Position the wiper off the centertap position a distance of at least 10% of potentiometer travel.

e. Connect the output of both potentiometer elements (centertap to wiper) to two channels of a Sanborn recorder for continuous recording of potentiometer output during this test.

f. Measure the output voltage with a Fluke voltmeter and record this voltage on the oscillograph recording.

g. Increase the ambient temperature and stabilize at 275 ± 5°F.

h. Remove the excitation voltage and instrumentation. Measure pin-to-pin resistances.

i. Reconnect the excitation voltage and instrumentation. Remain at 275°F for eight (8) hours.

j. After eight hours, measure pin heights as in paragraph 6.2.1c. Record the output voltage, as measured by the Fluke meter, on the oscillograph recording.

k. Repeat (h) above.

l. Reconnect the excitation voltage and measurement instrumentation. Lower temperature and stabilize at room ambient.

m. Repeat (f), (h), and (c) above.

n. Return units to Receiving Inspection for performance tests.

6.2.3 Humidity Test

a. Place both potentiometers in the humidity chamber. No electrical connections will be made. Install thermocouples and connect to the temperature recorder to continuously record wet and dry bulb temperatures of the chamber.

b. Apply ten (10) test cycles per MIL-E-5272C, Procedure I, maintaining 95-100% relative humidity. Each cycle consists of the following:

Time - Hrs.	Temperature
0	68 - 100° F
0 - 2	Raise to 160° F
2 - 8	Hold at 160° F
8 - 24	Lower to 68-100° F

c. At the completion of the ten cycles, remove the potentiometers from the test chamber, wipe off excess moisture, and allow both units to dry for 45 minutes in free air; at room conditions.

d. Measure pin-to-pin resistances per paragraph 6.2.1b insulation resistance within one (1) hour after completion of the final humidity cycle.

7.0 TEST RESULTS

The test results are summarized in both tabular form and plots, with amplifying remarks and comments in the following paragraphs. An index is shown below.

Test	S/N 3MG010AR	S/N 3U654AR
Performance Test Data	Table I	Table II
Linearity Plots		
Initial Performance	Figure 1, 2	Figure 11, 12
Post 0° F Soak and Operation	Figure 3, 4	Figure 13, 14
Post 275° F Soak and Operation	Figure 5, 6	Figure 15, 16
Post Humidity	Figure 7, 8	Figure 17, 18
Post Rework	Figure 9, 10	Figure 19, 20
Post Humidity		Figure 21, 22
Post 0° F Soak and Operation		Figure 23, 24
Post 275° F Soak and Operation (Final Performance)		Figure 25, 26
Potentiometer Resistance Readings During Testing	Table III	
Voltage Readings During 275° F Soak & Operation Test	Table IV	
Potentiometer Resistance Readings (Trial II)		Table V
Voltage Readings During 275° F Soak & Operation Test (Trial II)		Table VI

7.1 Trial I

During Trial I both potentiometers met all test and specification requirements except two--electrical noise, and insulation resistance following humidity testing.

The electrical noise, as noted in Table II, only appeared twice during the entire test program and on only one element of one potentiometer, S/N 3U654AR. Since it disappeared after some usage of the potentiometer, it was assumed that the noise was caused by some "built in" particles on the wiper assembly. This was discussed with Mr. Chester Martin, NASA Technical Representative, who approved continuation of testing. No electrical noise was measured following the continuation of tests.

At the end of the scheduled program, during the post-humidity performance test, both specimens failed the insulation resistance test from circuits to case and also between circuits. This failure is discussed in section 7.2.

Table III tabulates the element resistances which were measured before, during, and after the temperature tests. Table IV presents the input and output voltages of the specimens before, during, and after the high temperature test. The oscillograph recording of (4) output signals showed continuity throughout the high temperature test.

Connector pin heights did not change significantly throughout Trial I. The maximum change at high temperature was <0.004 inches, which included the thermal growth of the measuring block. The maximum permanent change in pin heights, measured at room temperature, was <0.0008 inches. These measurements proved to be of no significance inasmuch as the Silastic potting compound had been omitted from the junction box cavity (see section 7.2).

7.2 Humidity Test Failure - Discussion

On July 7, 1964, a failure investigation was begun on S/N 3MG010AR with Paul De Luca, Markite Engineering, attending. Prior to disassembly, the unit had dried out to where the insulation resistance at 500 VDC was 0.1 megohm. Upon disassembly of the connector, it was discovered that there was no Silastic RTV potting compound in the connector cavity. Also, instead of a compressable foam insert, there was a solid silicone rubber block 1/2 inch square by 3/16 inch thick.

Removing the pin subassembly from the connector, the following insulation resistance measurements were made:

a. All pins to connector shell: 0.5 megohms

b. All pins to potentiometer case: >100 megohms

c. All pins to OD of the stycast potting compound (measured by twisting wire tightly around potting compound to make contact): 10 megohms

Upon removing the connector junction box from the potentiometer case flange, corrosion was found on the interface of these parts.

It was noted that the inner end of the printed circuit conduct was sealed with Silastic RTV as shown on the Markite assembly drawing.

From this failure investigation, Moog and Markite made the following conclusions:

a. The insulation resistance failure occurred at the connector/printed circuit strip junction, not at the potentiometer elements or in the printed circuit strip.

b. The stycast potting exhibited low insulation resistance and was assumed to be the path for leakage to ground and between circuits.

c. Absence of silastic potting in the junction box cavity contributed to, and very probably is solely responsible for, the exposure of the stycast material to humidity. (It is remotely possible for the connector header-to-pin seal to have been inadequate).

d. Lack of silastic potting in the junction box cavity was an unauthorized deviation from the original design. The omission was apparently caused by an inadequate definition on the Markite drawing of the extent of the silastic potting.

7.3 Corrective Action

The following corrective action was agreed upon between Moog and Markite for all future units and was accomplished prior to Trial II.

a. The exterior surface of the stycast potting compound, which encapsulates the connector/printed circuit junction, will be coated with an insulating varnish for moisture protection.

b. The rubber pad in the junction box cavity will be replaced by a polyurethane foam pad, or equivalent, in accordance with the original redesign recommendations.

c. The junction box cavity will be filled with silastic upon assembly and the Markite assembly drawing changed accordingly.

d. The two qualification test units, only, will be baked at 160° F prior to rework so as to drive out residual moisture from the humidity test of Trial I.

7.4 Trial II

7.4.1 Trial II Test Plan

Because the potentiometer failure experience had been in the high temperature (operating) and the humidity environments, it was necessary that at least these two tests be repeated after the corrective action described in section 7.3 was effected. Also, it was considered desirable to repeat the low temperature storage test because it was inexpensive and would complete the Trial II program as a complete repetition of Trial I. Thus, it was agreed between Moog and NASA technical representatives that Trial II would constitute a complete rerun of Trial I.

Both specimens were reworked by Markite, as described in section 7.3, and were returned to Moog for Trial II testing. One unit, S/N 3MG010AR, was subsequently dropped from the program as explained in the following section.

7.4.2 Dropout of S/N 3MG010AR

After rework by Markite, this unit failed Moog's receiving inspection for low insulation resistance between circuits. Also, the insulation resistance from circuits to case was only marginally above the minimum requirement. This unit was returned to Markite for repair but Markite overlooked the fault between circuits, so when returned to Moog the unit was still unsatisfactory.

The insulation resistance failures of this unit which occurred following the first and second reworks are attributed to damage of the printed circuit during rework operations. These failures were reviewed at a meeting at Markite on 7/30/64 attended by Moog Q.C. and Purchasing representatives and by Markite and NASA Engineering and Q.C. representatives. At that meeting it was demonstrated that the subject specimen had a weak spot in the insulation of the printed circuit strip which allowed electrical leakage when subjected to moisture.

It was subsequently determined by NASA Engineering that the margin of insulating plastic between conducting strip and exterior surface of the strip assembly did not meet Markites' dimensional tolerance specification, whereas the printed circuit strip of another potentiometer available to NASA did meet these tolerances. Thus, it appears that substandard quality of the printed circuit was a contributing factor to the post rework insulation resistance failures of S/N 3MG010AR. The printed circuit/electrical connector assembly is manufactured by Sanders Associates, Nashua, New Hampshire.

Markite was advised by a NASA technical representative that in repairing S/N 3MG010AR it would be necessary to provide a new printed circuit/connector assembly rather than attempt further repair of the damaged printed circuit. Before this could be accomplished, however, the Trial II tests of the other unit were complete and the qualification test funds were nearly expended. Inasmuch as NASA could not authorize additional funding it was agreed that further test activity would be cancelled and the balance of funds devoted to documentation effort.

7.4.3 Trial II Performance of S/N 3U654AR

The performance of S/N 3U654AR during Trial II was completely satisfactory with the exception of a minor discrepancy in linearity at a wiper position of 0.5 in. from centertap on element #2. Since this particular point was marginal upon return from rework, and the output ratio at this point deteriorated only 0.0002 during the tests of Trial II, the performance was considered acceptable for the purpose of the Trial II program.

The oscillograph recording of potentiometer output signals during the high temperature soak test showed signal continuity throughout the test.

Photographs of the electrical connector taken before, during, and after the high temperature test gave no evidence of internal pressure in the junction box cavity. Specifically, the electrical connector flange/junction box interface was inspected for separation, which would have indicated internal pressure from expansion of the silastic potting compound. Electrical connector pin heights which were essentially unchanged by the humidity and low temperature tests, showed only a small permanent increase of .002 to .0034 inch due to the high temperature test.

Performance data is presented in Tables II, V, and VI.

TABLE I
Performance Data Tabulation - S/N 3MG010AR

MODEL 062-42282 S/N 3MG010AR		INITIAL PERFORMANCE	POST 0°F SOAK & OPERATION	POST 275°F SOAK & OPERATION	FINAL PERFORMANCE	POST REWORK No. 1	POST REWORK No. 2
INSULATION RESISTANCE (MΩ)							
ELEM #1 PINS TO CASE		30000	20,000	20,000	SHORT	70	1900
ELEM #2 PINS TO CASE		35000	10,000	2,000	SHORT	60	1900
A-E		20000	[illegible]	3,500	SHORT	<15	.35
ELEMENT RESISTANCE							
A-C		5070	5134	5099	5114	5130	5148
E-G		5110	5112	5122	[illegible]	5166	5197
B-D		.560	559	566	558	[illegible]	581
F-H		550	557	560	564	575	[illegible]
RESISTANCE DIRECTION							
A-B		OK	OK	OK	OK	OK	OK
B-D		OK	OK	OK	OK	OK	OK
B-C		OK	OK	OK	OK	OK	OK
E-F		OK	OK	OK	OK	OK	OK
F-H		OK	OK	OK	OK	OK	OK
F-G		OK	OK	OK	OK	OK	OK
ELECTRICAL NOISE (Ω)							
ELEM. #1		0	[illegible]	0	0	0	50
ELEM. #2		0	0	0	0	0	[illegible]
MECHANICAL TRAVEL							
ELEM. #1	C.T. TO RET.	5.198	5.197	5.190	–	5.144	[illegible]
	C.T. TO EXT.	–	5.235	–	–	[illegible]	[illegible]
ELEM. #2	C.T. TO RET.	–	5.125	5.184	–	[illegible]	[illegible]
	C.T. TO EXT.	–	5.240	–	–	[illegible]	5.221
DEVIATION BETWEEN C.T.S		.0045	[illegible]	[illegible]	–	[illegible]	[illegible]
RESOLUTION							
ELEM. #1		∞	∞	∞	∞	∞	∞
ELEM #2		∞	∞	∞	∞	∞	∞
ELECTRICAL TO MECH.		[illegible]	[illegible]	[illegible]	–	[illegible]	[illegible]
LINEARITY PLOTS							
ELEM #1		FIG. 1	FIG. 3	FIG. 5	FIG. 7	FIG. 9	–
ELEM #2		FIG. 2	FIG. 4	FIG. 6	FIG. 8	FIG. 10	

TABLE II

Performance Data Tabulation - S/N 3U654AR

MODEL [illegible]
S/N 3U654AR

	INITIAL PERFORMANCE	POST 0°F SOAK & OPERATION	POST 275°F SOAK & OPERATION	FINAL PERFORMANCE	POST REWORK	POST HUMIDITY	POST 0°F SOAK & OPERATION	POST 275°F SOAK & OPERATION		
						7-27	7-28	7-29		
INSULATION RESISTANCE (MΩ)										
ELEM #1 PINS TO CASE	40,000	10,000	10,000	SHORT	5000	3500	1800	3000		
ELEM #2 PINS TO CASE	40,000	25,000	10,000	SHORT	5000	6,000	2800	7600		
A - E	800,000	35,000	10,000	SHORT	2000	9000	4000	3000		
ELEMENT RESISTANCE (Ω)										
A - C	4980	4988	5035	5097	5083	5150	5142	5120		
E - G	4700	4709	4747	4808	4793	4850	4847	4835		
B - D	562	561	574	588	590	599	589	575		
F - H	532	534	533	548	553	579	570	550		
RESISTANCE DIRECTION										
A - B	OK	OK	OK	OK	OK	OK	OK	OK		
B - D	OK	OK	OK	OK	OK	OK	OK	OK		
B - C	OK	OK	OK	OK	OK	OK	OK	OK		
E - F	OK	OK	OK	OK	OK	OK	OK	OK		
F - H	OK	OK	OK	OK	OK	OK	OK	OK		
F - G	OK	OK	OK	OK	OK	OK	OK	OK		
ELECTRICAL NOISE (Ω)										
ELEM. #1	*150	0	**>200	0	0	0	0	0		
ELEM #2	0	0	10	0	0	0	0	0		
MECHANICAL TRAVEL										
ELEM. #1 C.T. TO RET.	—	5.205	5.202	—	5.212	5.213	5.214	5.214		
ELEM. #1 C.T. TO EXT.	—	5.222	—	—	5.227	5.225	5.221	5.231		
ELEM. #2 C.T. TO RET.	—	5.202	5.194	—	5.214	5.210	5.215	5.217		
ELEM. #2 C.T. TO EXT.	—	5.225	—	—	5.224	5.228	5.220	5.227		
DEVIATION BETWEEN C.T.S	.0015	.0030	.0080	—	.0020	.0030	.0010	.0030		
RESOLUTION										
ELEM. #1	∞	∞	∞	∞	∞	∞	∞	∞		
ELEM. #2	∞	∞	∞	∞	∞	∞	∞	∞		
ELECTRICAL TO MECH.	19.778	19.773	19.770	—	19.776	19.778	19.779	19.753		
LINEARITY PLOTS										
ELEM. #1	FIG. 11	FIG. 13	FIG. 15	FIG. 17	FIG. 19	FIG. 21	FIG. 23	FIG. 25		
ELEM. #2	FIG. 12	FIG. 14	FIG. 16	FIG. 18	FIG. 20	FIG. 22	FIG. 24	FIG. 26		

* NOISE SPIKE LASTED 5 CYCLES THEN DISAPPEARED

** INTERMITTENT SINGLE SPIKE

TABLE III
Potentiometer Resistance Readings
During Temperature Tests (Trial I)

	Pins	Pre 0° F Soak & Oper.	@ 0° F	Diff.	Post 0° F Soak & Oper.	Diff. from Original	
		@ 75° F			@ 70° F		
S/N 3U654AR	A-C	4982	5067	+85	4973	- 9	
	E-G	4702	4782	+80	4710	+ 8	
	D-B	1039	1053	+14	1041	+ 2	
	H-F	984	998	+14	985	+ 1	
S/N 3MG010AR	A-C	5072	5161	+89	5090	+22	
	E-G	5110	5200	+90	5152	+42	
	D-B	1033	1048	+15	1036	+ 3	
	H-F	1040	1055	+15	1042	+ 2	
Test Date		6/18/64	6/18/64		6/18/64		

	Pins	Pre 275° F Soak & Oper.	@ 275° F	Diff.	After 8 hrs. Soak@ 275° F	Diff. after 8 hrs.	Post 275° F Soak & Oper.	Diff. Pre & Post 275° F
		@ 78° F	@274° F		@277° F		@ 79° F	
S/N 3U654AR	A-C	4982	4967	-15	4976	- 9	5037	+55
	E-G	4702	4687	-15	4692	- 5	4753	+51
	D-B	1001	1008	+ 7	1012	- 4	1013	+12
	H-F	948	957	+ 9	956	+ 1	959	+11
S/N 3MG010AR	A-C	5069	5009	-60	5015	+ 6	5079	+10
	E-G	5108	5045	-63	5052	- 7	5122	+14
	D-B	1000	997	- 3	999	- 2	1002	+ 2
	H-F	1006	1004	- 2	1005	- 1	1009	+ 3
Test Date		6/22/64	6/22/64		6/22/64		6/22/64	

TABLE IV
Voltage Readings During 275° F Soak & Operation Test
(Trial I)

*	Pins	at Room Temperature Pin Voltage	E_o/E_s	at 275° F Pin Voltage	E_o/E_s	After 8 hrs. at 275° F Pin Voltage	E_o/E_s	Post 275° F at 79° F Pin Voltage	E_o/E_s
S/N 3U654AR	A-C	59.72		59.90		59.93		59.97	
	E-G	9.972		10.008		10.012		9.996	
	D-B	5.383	.09014	5.472	.09135	5.471	.09128	5.364	.08944
	H-F	0.897	.08995	0.913	.09123	0.9131	.09120	0.8930	.08934
S/N 3MG010AR	A-C	59.74		59.75		59.80		59.94	
	E-G	9.983		9.986		9.986		9.977	
	D-B	5.359	.08971	5.434	.09095	5.443	.09102	5.363	.08947
	H-F	0.894	.08955	0.905	.09063	0.9056	.09069	0.8920	.08941

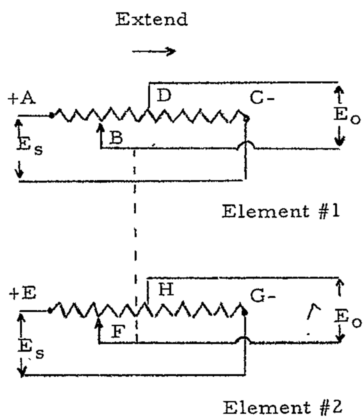


TABLE V
Potentiometer Resistance Readings
During Temperature Tests (Trial II)

Pins	Pre 0° Soak & Oper. 85°F	@ 0°F	Diff.	Post 8 hrs. Soak at 0°F	Diff. 8 hrs.	Post 16 hrs. Soak at 0°F	Diff. 16 hrs.	Post 0°F Soak & Oper. 74°F	Diff. Pre & Post
A-C	5132	5185	+53	5200	+15	5202	+17	5146	+14
E-G	4840	4893	+53	4900	+ 7	4907	+14	4854	+14
D-B	1001	1014	+13	1015	+ 1	1014	0	1001	0
H-F	950	959	+ 9	961	+ 2	961	+ 2	951	+ 1
Date	7/27/64	7/27/64		7/27/64		7/28/64		7/28/64	

Pins	Pre 275°F Soak & Oper. @ 81°F	@ 275°F	Diff.	Post 8 hrs. at 275°F	Diff. 8 hrs.	Post 275°F Soak & Oper. @ 95°F	Diff. Pre & Post 275°F
A-C	5130	5046	-84	5060	+14	5115	-15
E-G	4844	4766	-78	4773	+ 7	4830	-14
D-B	1000	992	- 8	995	+ 3	1010	+10
H-F	948	942	- 6	943	+ 1	957	+ 9
Date	7/28/64	7/28/64		7/29/64		7/29/64	7/29/64

TABLE VI

Voltage Readings During 275° F Soak & Operation Test
(Trial II)

Pins		E_o/E_s	at 275° F	E_o/E_s	Post 275° F at 275° F	E_o/E_s	Post 275° F Soak & Oper. at 92° F	E_o/E_s
	81° F							
A-C	58. 32		58. 27		58. 40		58. 51	
E-G	9. 652		9. 662		9. 660		9. 654	
D-B	4. 8219	. 082680	4. 8929	. 083966	4. 9028	. 083952	4. 8738	. 083299
F-H	. 7991	. 082791	. 8123	. 084072	. 8117	. 084221	0. 8047	. 083354
	7/29/64		7/29/64		7/29/64		7/29/64	

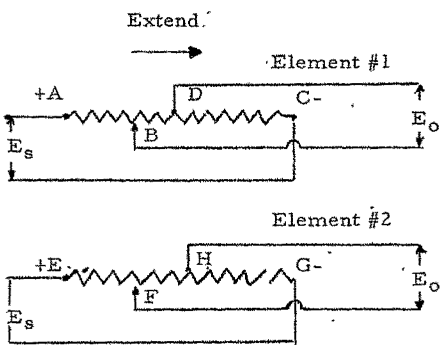


Figure 1

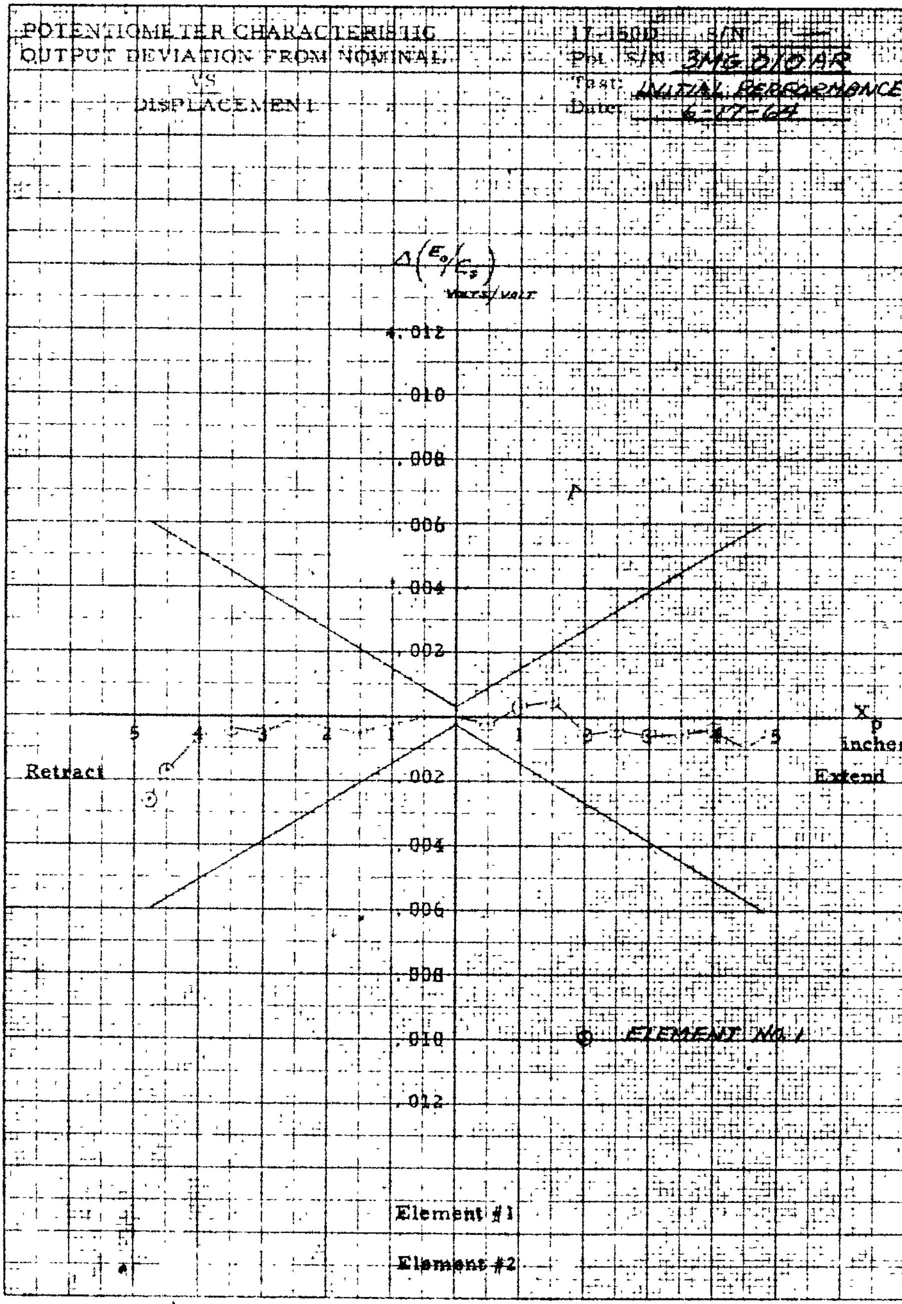

POTENTIOMETER CHARACTERISTIC
OUTPUT DEVIATION FROM NOMINAL
VS
DISPLACEMENT
Pot. S/N 3MG 010AR
Test: INITIAL PERFORMANCE
Date: 6-17-64
.012
.010
.008
.006
.004
.002
5
4
3
2
1
1
2
3
4
5
Retract
Extend
inches
ELEMENT NO. 1
Element #1
Element #2

Figure 2

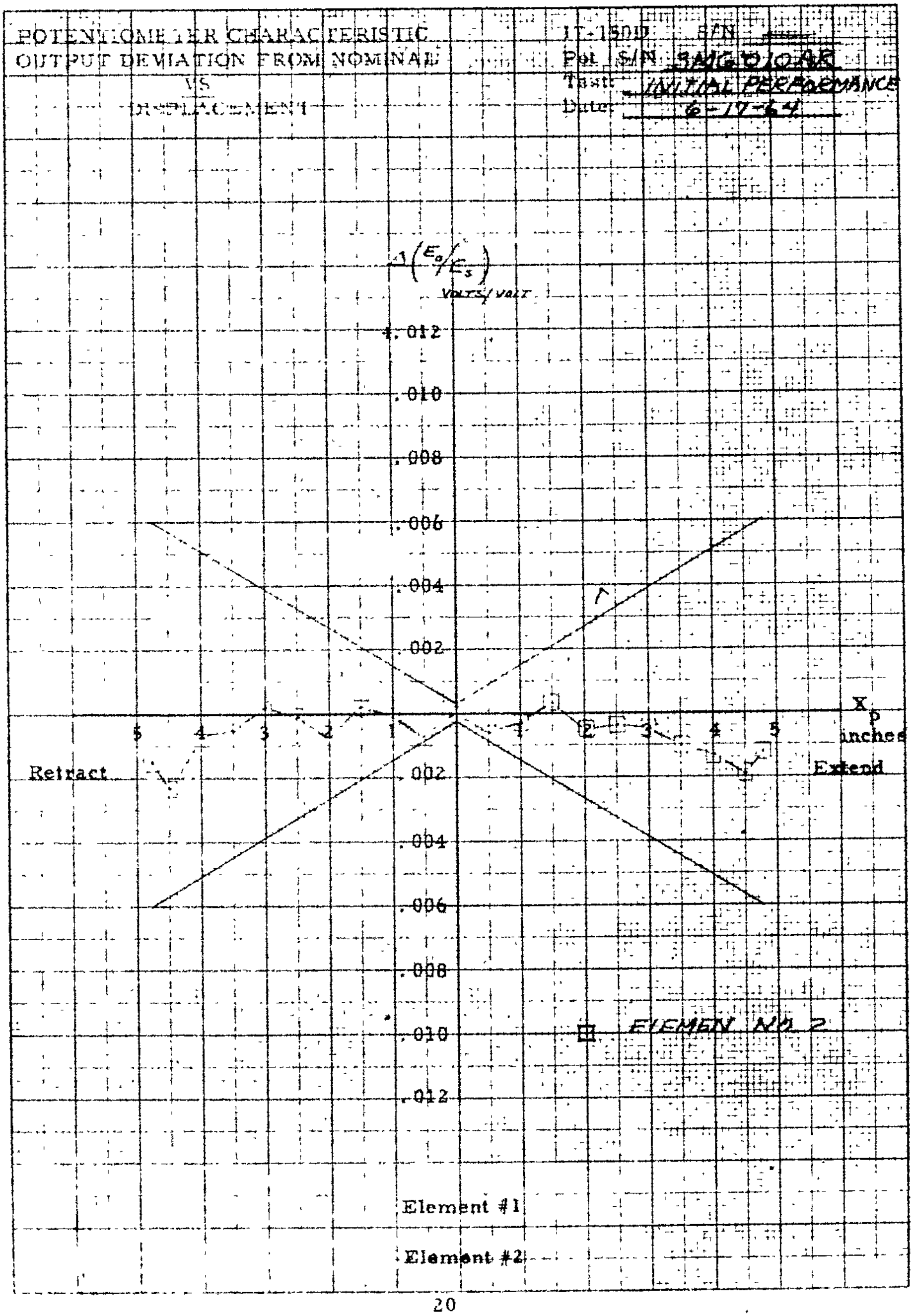

POTENTIOMETER CHARACTERISTIC
OUTPUT DEVIATION FROM NOMINAL
VS
DISPLACEMENT
Pot S/N
Test: INITIAL PERFORMANCE
Date: 6-17-64
Δ(Eo/Es) VOLTS/VOLT
.012
.010
.008
.006
.004
.002
5 4 3 2 1 1 2 3 4 5
Xp inches
Retract
Extend
ELEMEN NO. 2
Element #1
Element #2

Figure 3

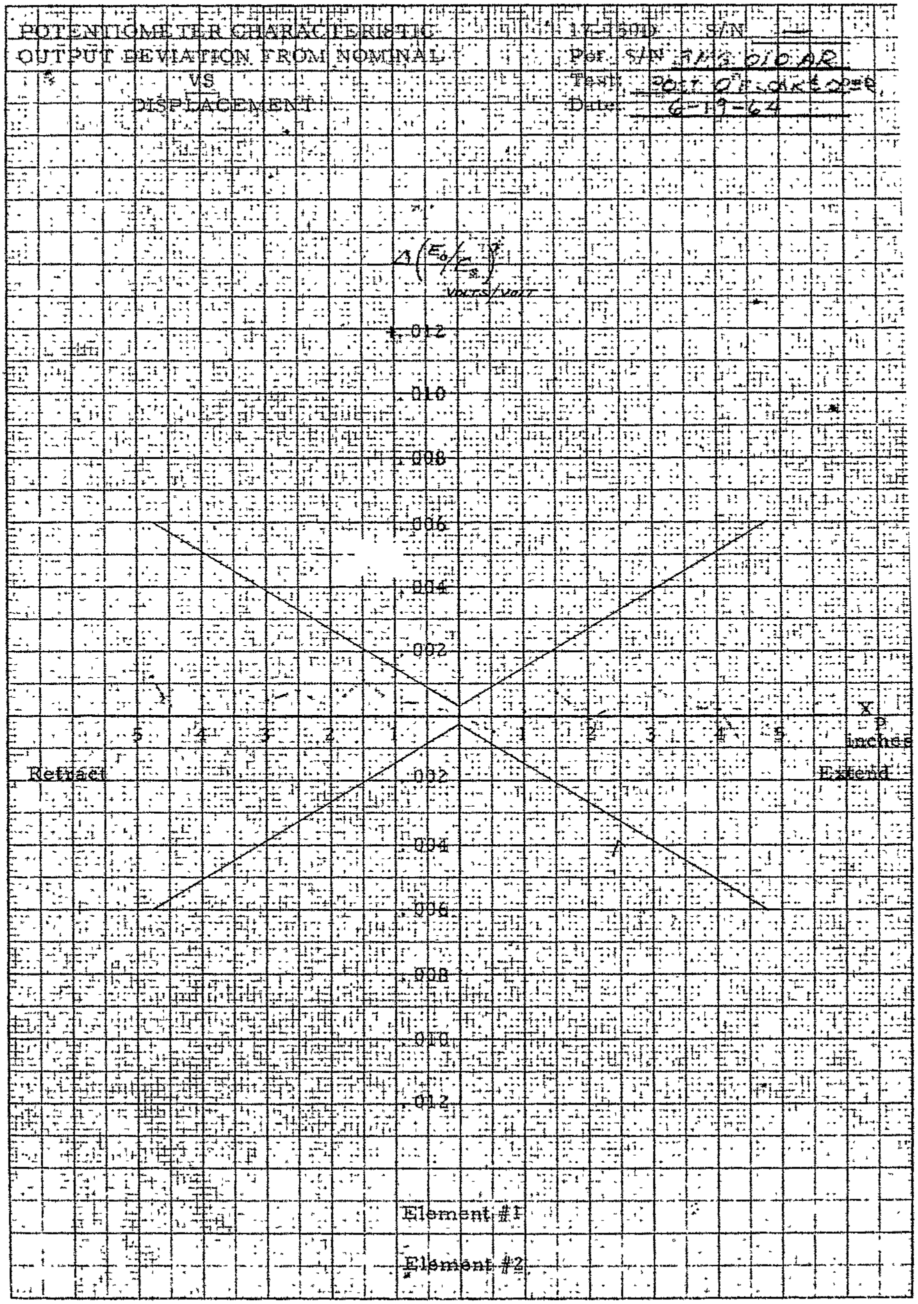

POTENTIOMETER CHARACTERISTIC
OUTPUT DEVIATION FROM NOMINAL
VS
DISPLACEMENT
S/N
Pot. S/N
Test:
Date: 6-19-64
Volts/Volt
.012
.010
.008
.006
.004
.002
5
4
3
2
1
1
2
3
4
5
X
D
inches
Retract
Extend
Element #1
Element #2

Figure 4

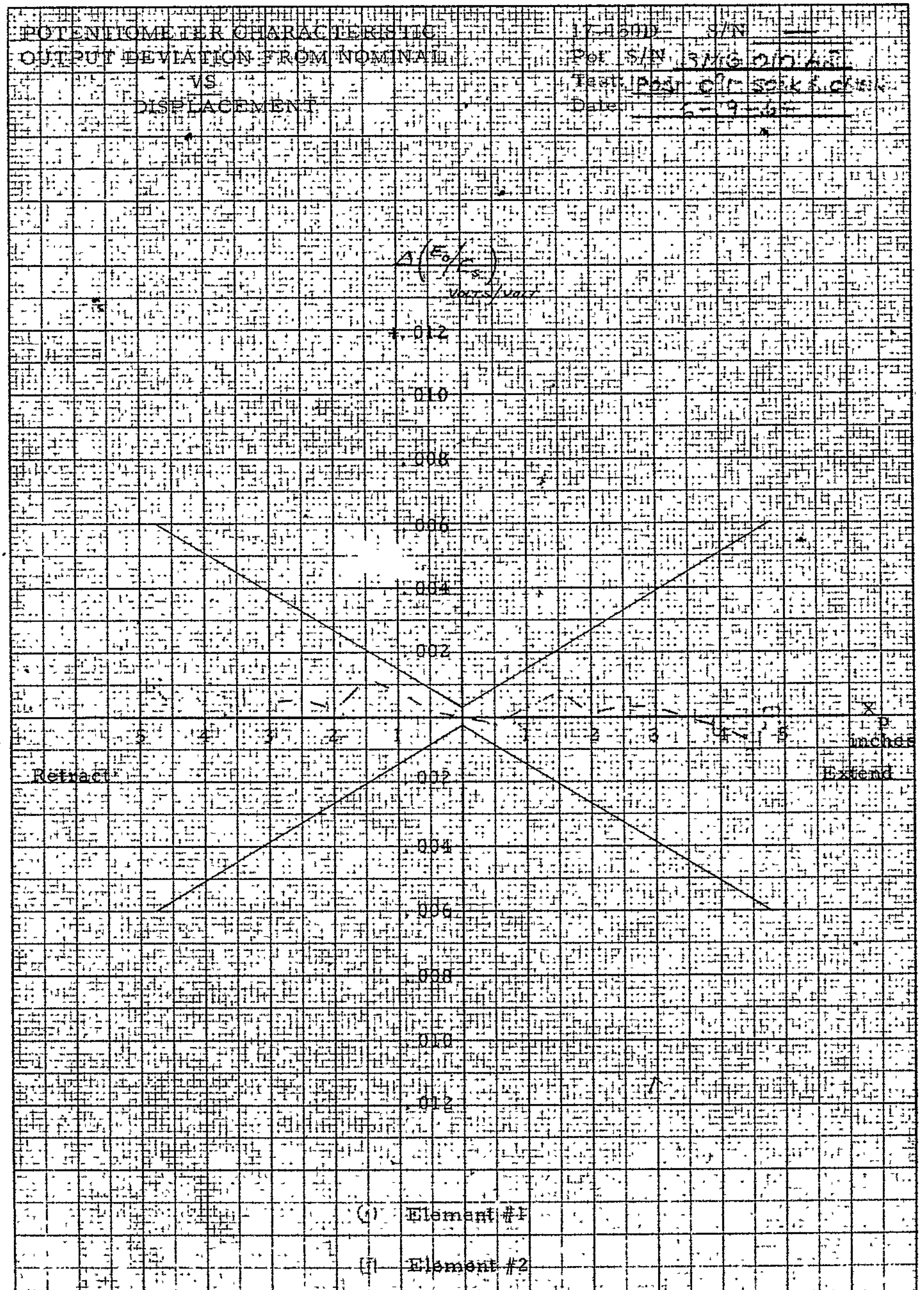
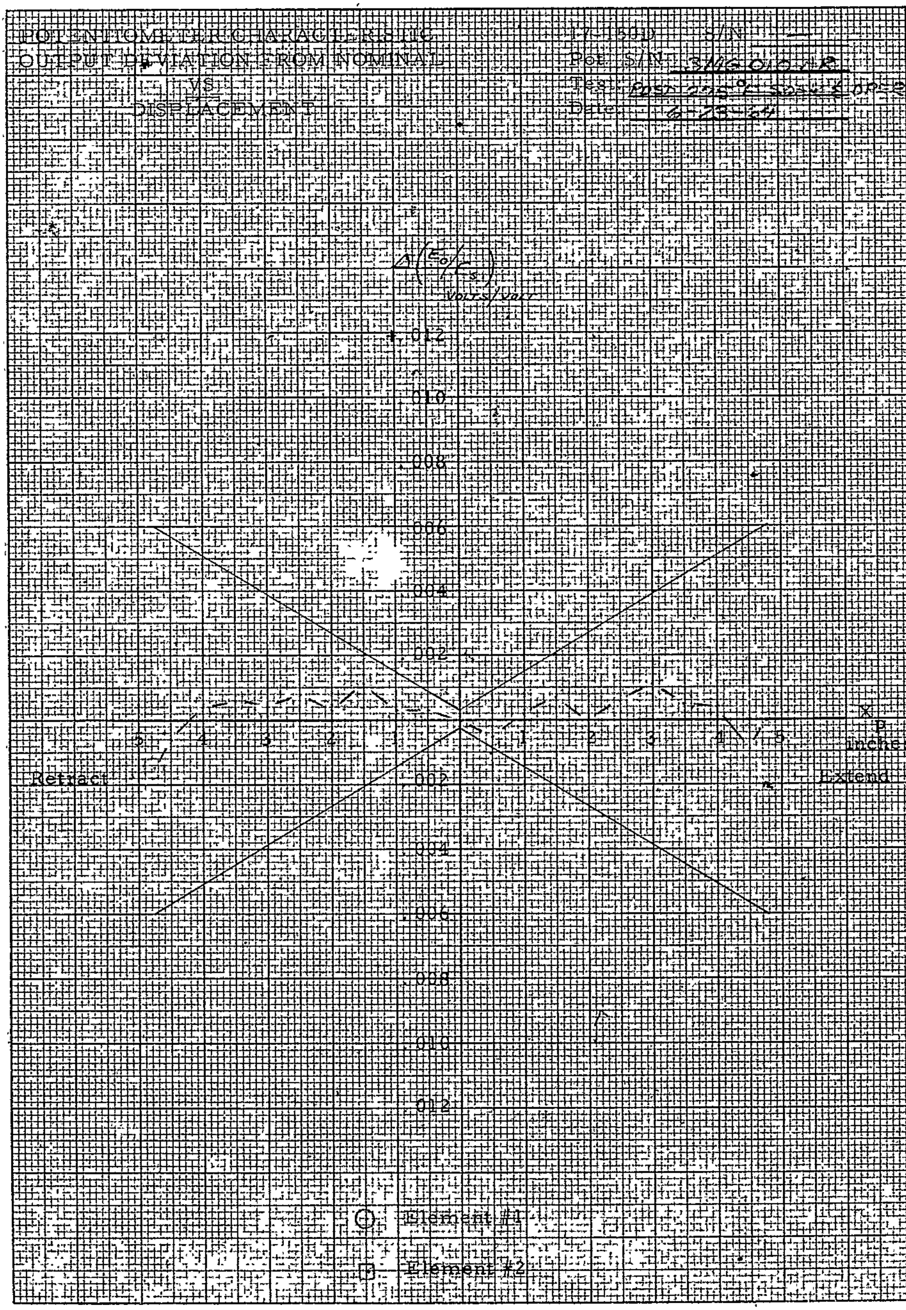

POTENTIOMETER CHARACTERISTIC
OUTPUT DEVIATION FROM NOMINAL
VS
DISPLACEMENT
Pot S/N
Test
Date
Δ(Eo/Es) volts/volt
+.012
.010
.008
.006
.004
.002
5
4
3
2
1
1
2
3
4
5
X p inches
Retract
Extend
.002
.004
.006
.008
.010
.012
(·) Element #1
[] Element #2

Figure 5



POTENTIOMETER CHARACTERISTIC
OUTPUT DEVIATION FROM NOMINAL
VS
DISPLACEMENT
Pot S/N
Test
Date
Volts/Volt
.012
.010
.008
.006
.004
.002
5
4
3
2
1
1
2
3
4
5
inches
Retract
Extend
.002
.004
.006
.008
.010
.012
Element #1
Element #2

Figure 6

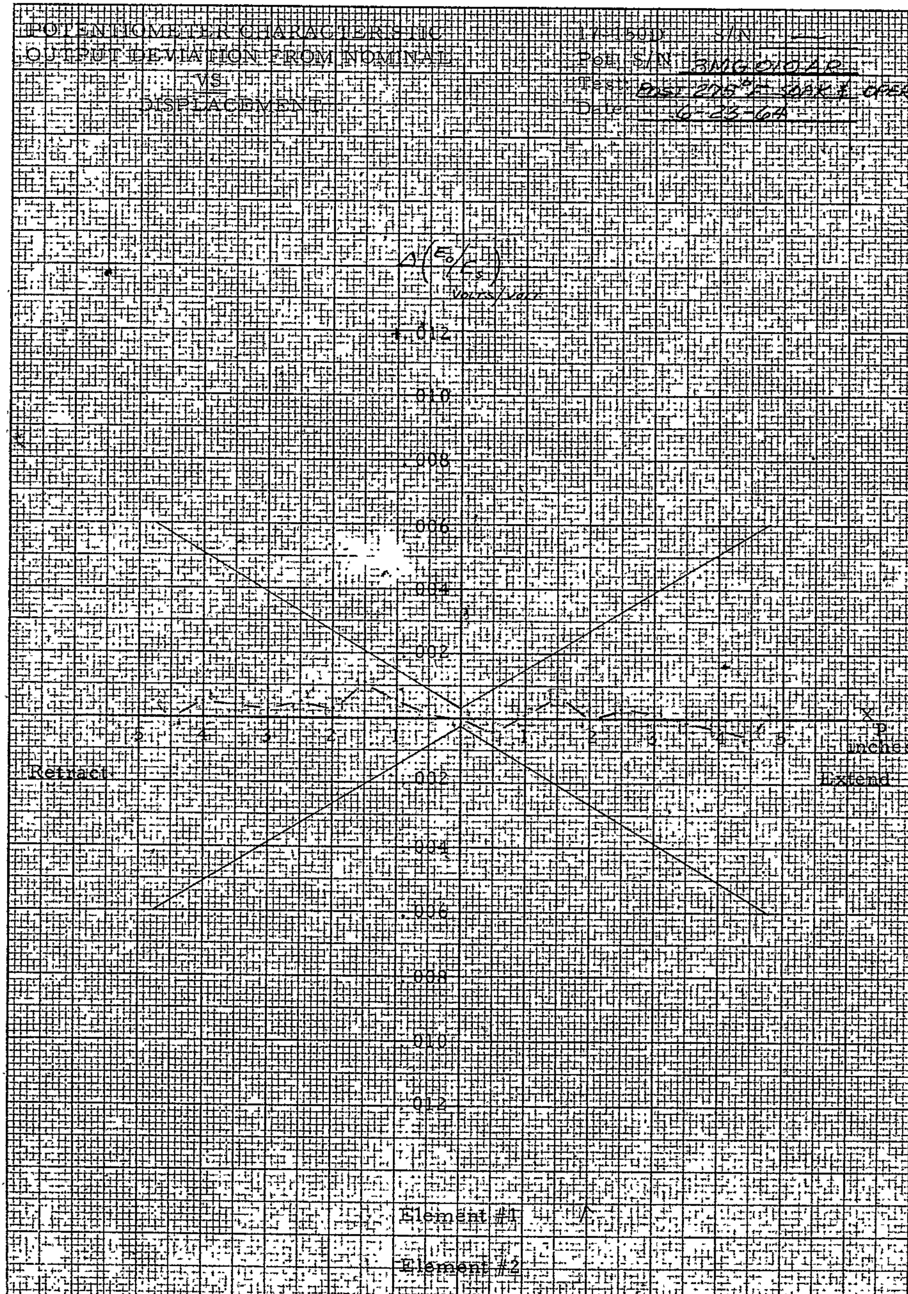

POTENTIOMETER CHARACTERISTIC
OUTPUT DEVIATION FROM NOMINAL
VS
DISPLACEMENT
Pot. S/N 3MG010AR
Test Post 275°F Soak & Oper
Date 6-23-64
Δ(Eo/Es)
VOLTS/VOLT
.012
.010
.008
.006
.004
.002
.002
.004
.006
.008
.010
.012
5
4
3
2
1
1
2
3
4
5
Xp
inches
Retract
Extend
Element #1
Element #2

Figure 7

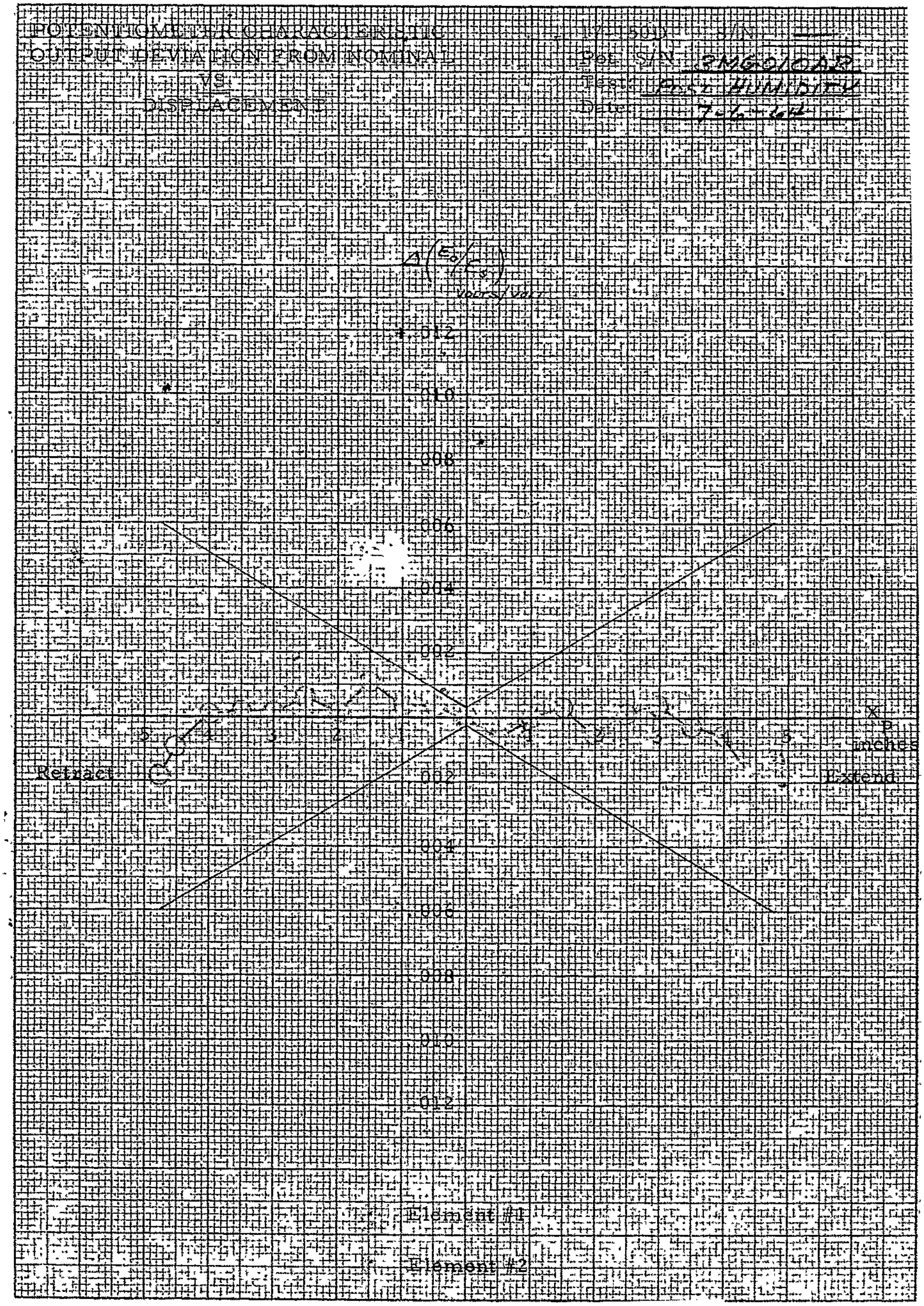

POTENTIOMETER CHARACTERISTIC
OUTPUT DEVIATION FROM NOMINAL
VS
DISPLACEMENT
Pot. S/N 3MG010AR
Test: Post HUMIDITY
Date 7-6-62
Δ(Eo/Es)
VOLTS/VOLT
+.012
.010
.008
.006
.004
.002
.002
.004
.006
.008
.010
.012
5
4
3
2
1
1
2
3
4
5
Xp
inches
Retract
Extend
Element #1
Element #2

Figure 8

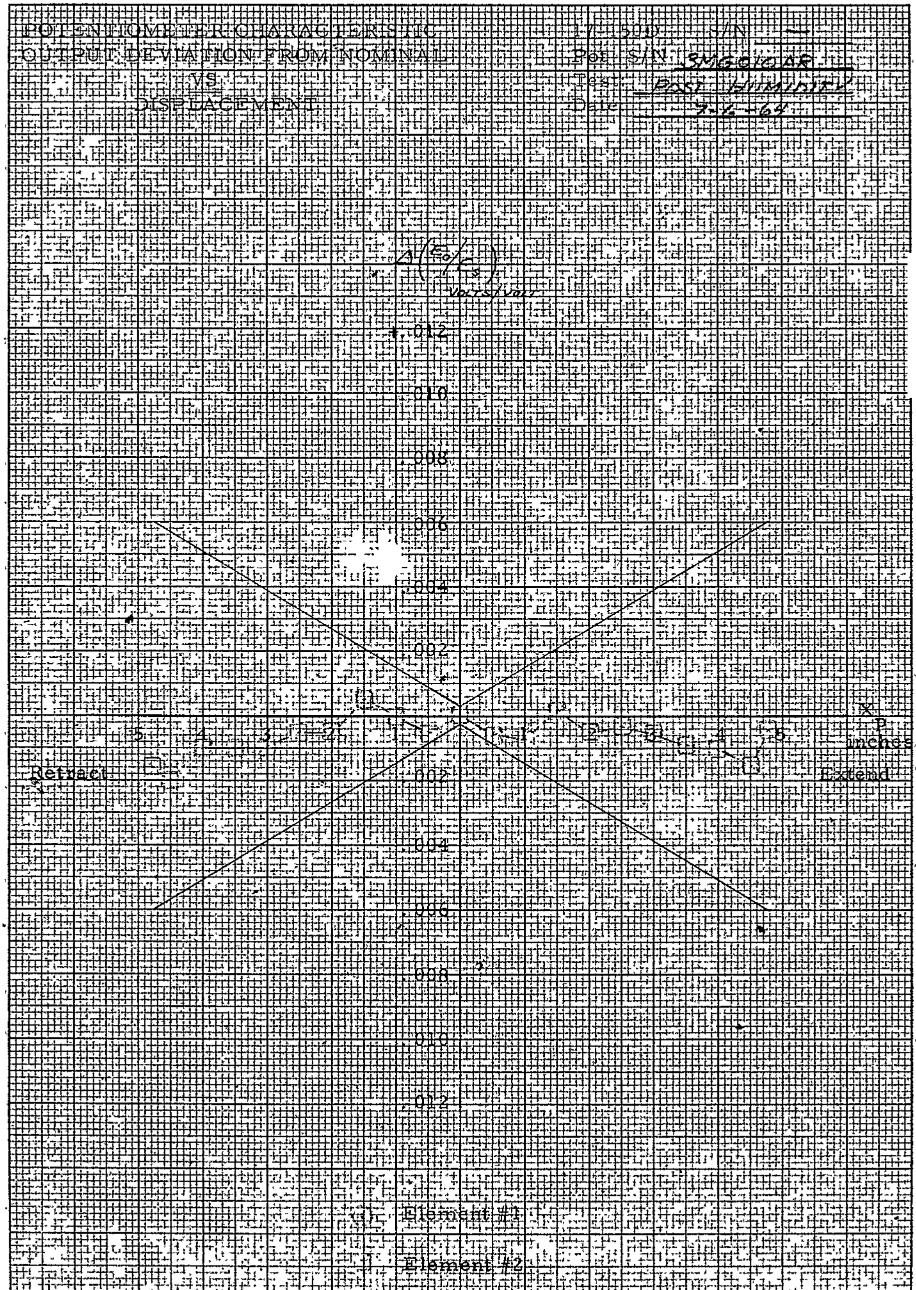

POTENTIOMETER CHARACTERISTIC
OUTPUT DEVIATION FROM NOMINAL
VS
DISPLACEMENT
17-1500 S/N —
Pot S/N SMG0104AR
Test POST HUMIDITY
Date 9-6-69
Δ(Eo/Ei) VOLTS/VOLT
+.012
.010
.008
.006
.004
.002
.002
.004
.006
.008
.010
.012
5
4
3
2
1
1
2
3
4
5
X P inches
Retract
Extend
(1) Element #1
Element #2

Figure 9

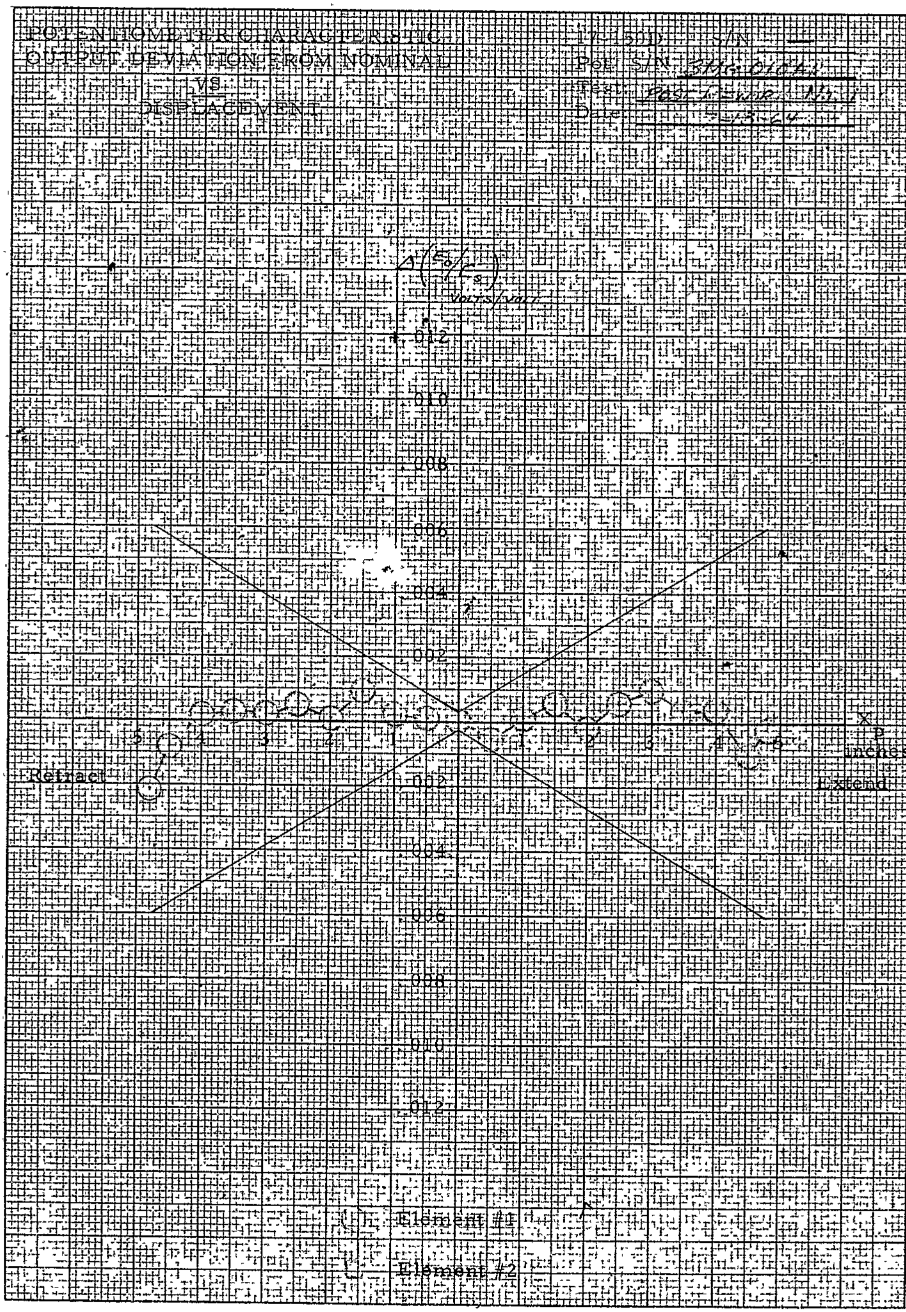
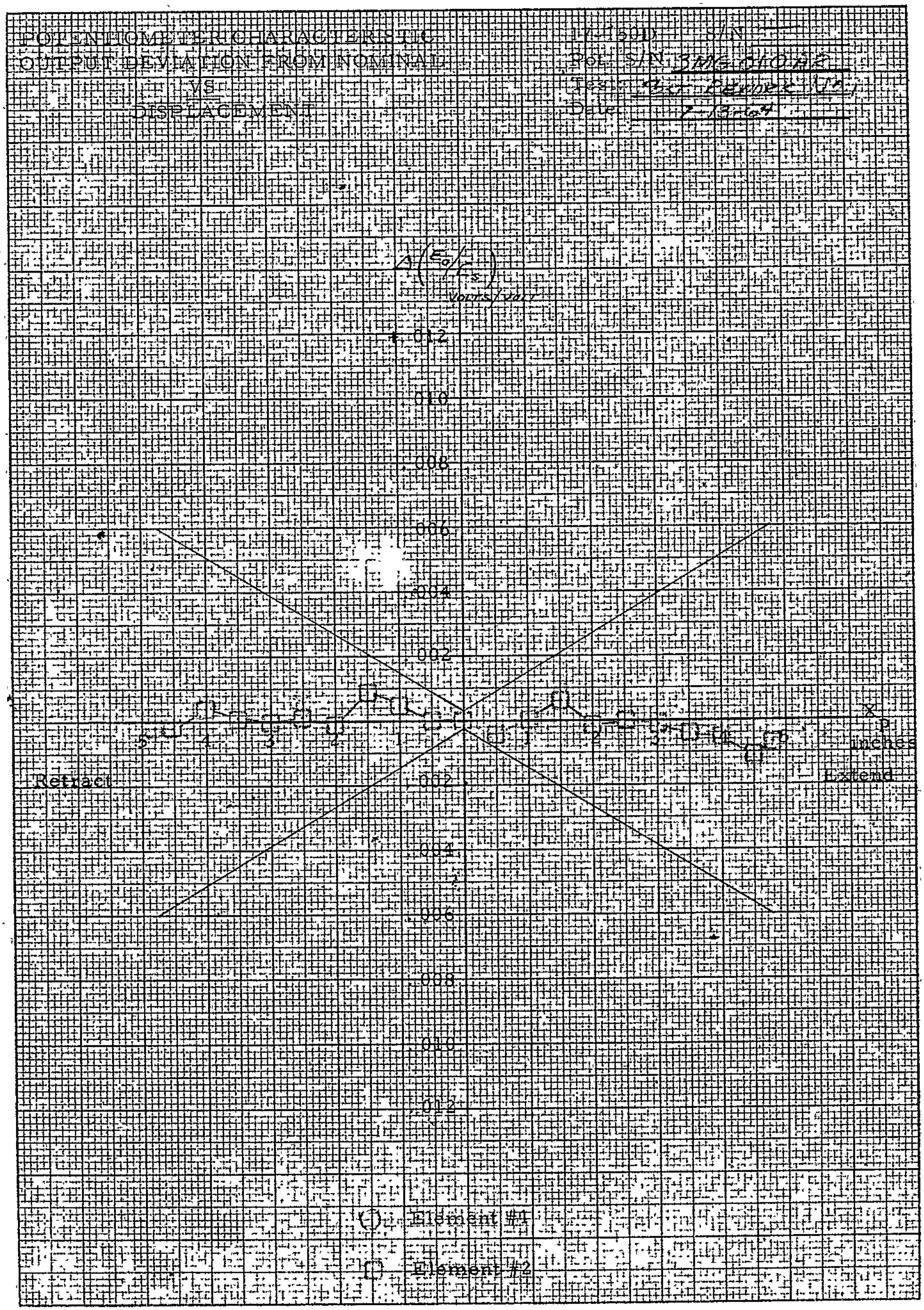

POTENTIOMETER CHARACTERISTIC
OUTPUT DEVIATION FROM NOMINAL
VS
DISPLACEMENT
S/N
Pot S/N
Test
Date
.012
.010
.008
.006
.004
.002
.002
.004
.006
.008
.010
.012
5
4
3
2
1
1
2
3
4
5
Retract
Extend
X_P
Inches
Element #1
Element #2

Figure 10



POTENTIOMETER CHARACTERISTIC
OUTPUT DEVIATION FROM NOMINAL
VS
DISPLACEMENT
S/N
Pot S/N
Test
Date
.012
.010
.008
.006
.004
.002
.002
.004
.006
.008
.010
.012
.5
.4
.3
.2
.1
.1
.2
.3
.4
.5
.6
X
P
inches
Retract
Extend
Element #1
Element #2

Figure 11

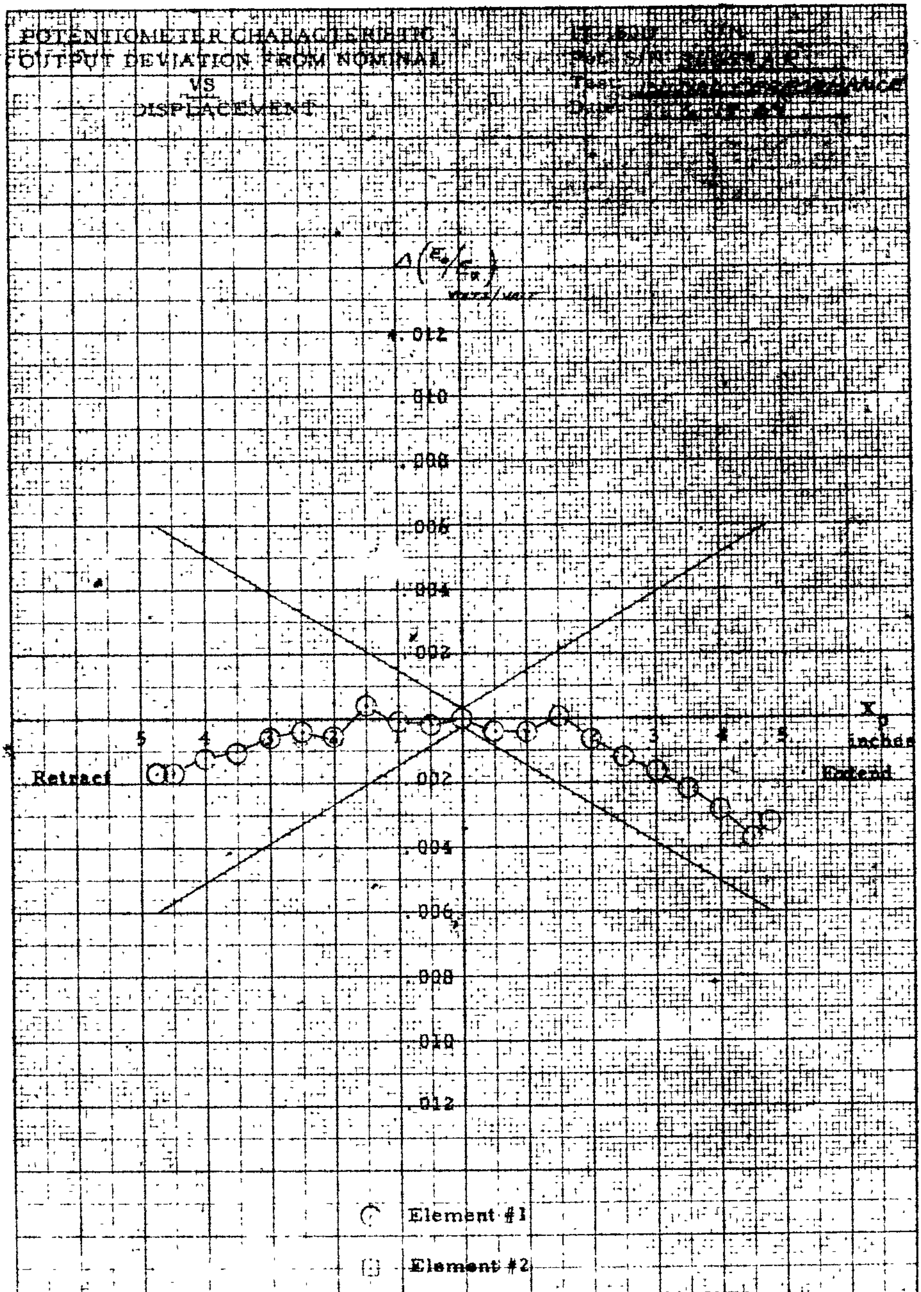

POTENTIOMETER CHARACTERISTIC
OUTPUT DEVIATION FROM NOMINAL
VS
DISPLACEMENT
.012
.010
.008
.006
.004
.002
.002
.004
.006
.008
.010
.012
5
4
3
2
1
1
2
3
4
5
Retract
Extend
inches
Element #1
Element #2

Figure 12

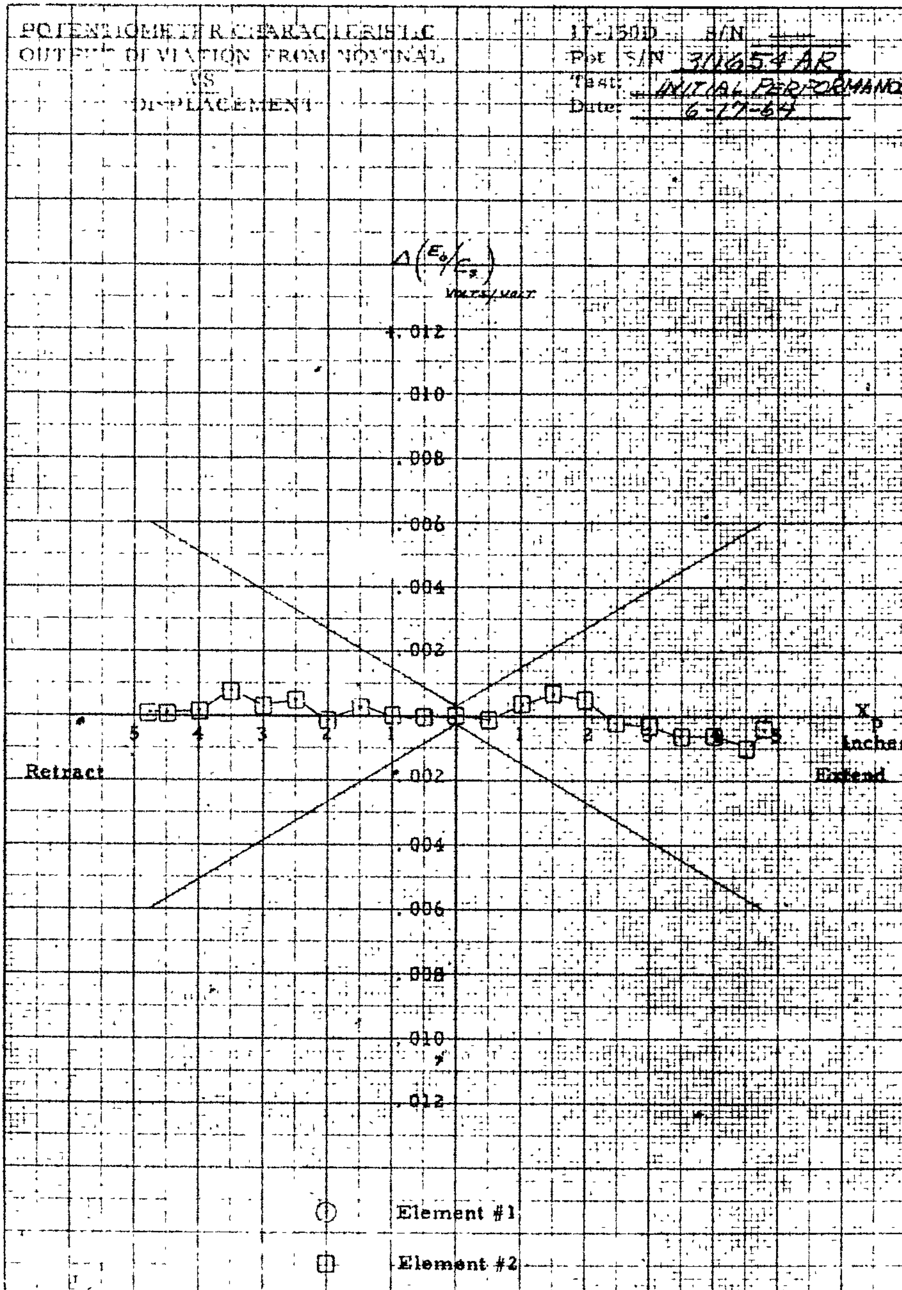

POTENTIOMETER CHARACTERISTIC
OUTPUT DEVIATION FROM NOMINAL
VS
DISPLACEMENT
LT-150D S/N
Pot S/N 3/1654AR
Test: INITIAL PERFORMANCE
Date: 6-17-64
$\Delta\left(E_o/E_s\right)$
VOLTS/VOLT
+.012
.010
.008
.006
.004
.002
.002
.004
.006
.008
.010
.012
5
4
3
2
1
1
2
3
4
5
X_p
Inches
Retract
Extend
Element #1
Element #2

Figure 13

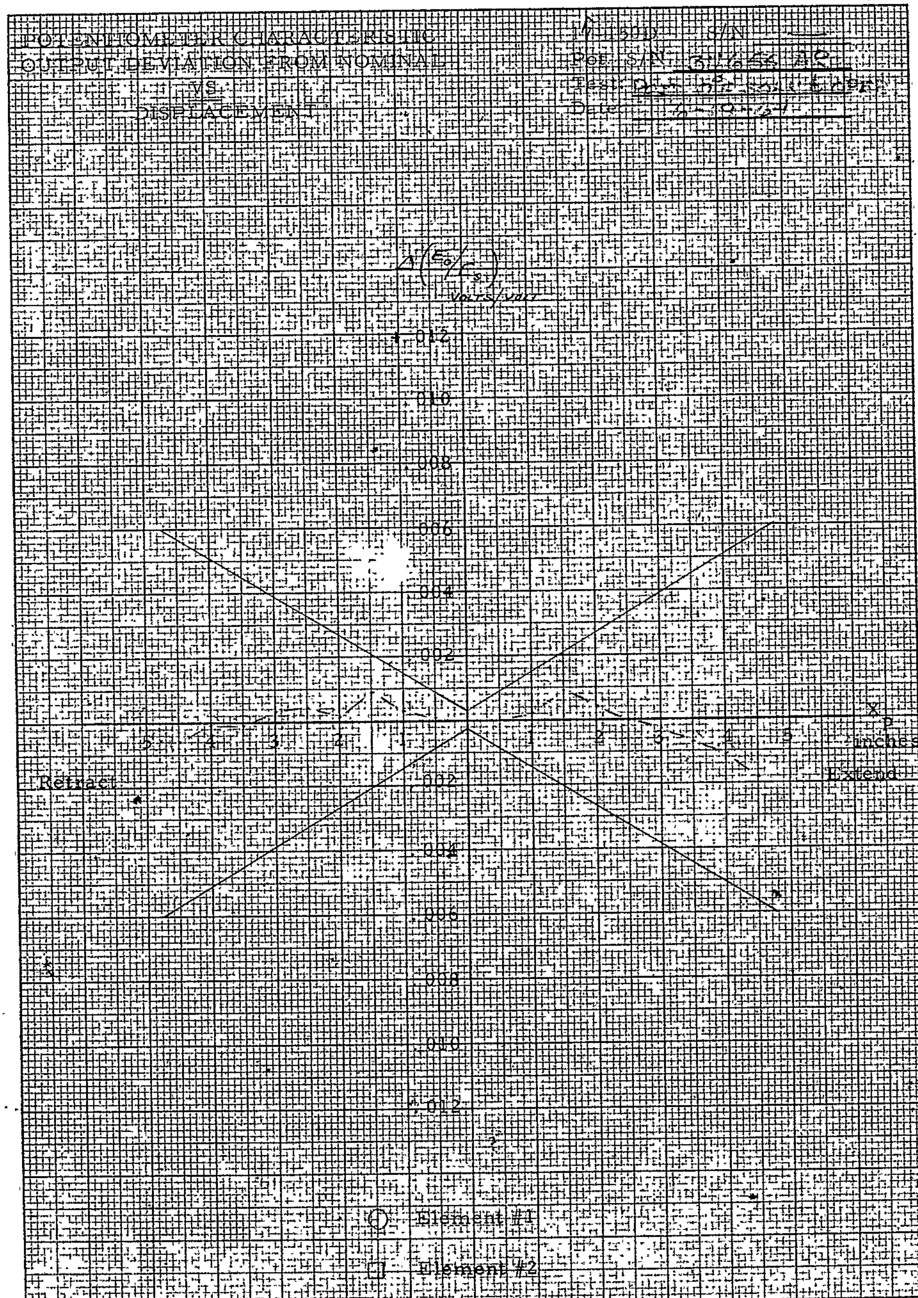

POTENTIOMETER CHARACTERISTIC
OUTPUT DEVIATION FROM NOMINAL
VS
DISPLACEMENT
Pot. S/N
Test
Date
.012
.010
.008
.006
.004
.002
5
4
3
2
1
1
2
3
4
5
X_p
inches
Retract
Extend
.002
.004
.006
.008
.010
.012
Element #1
Element #2

Figure 14

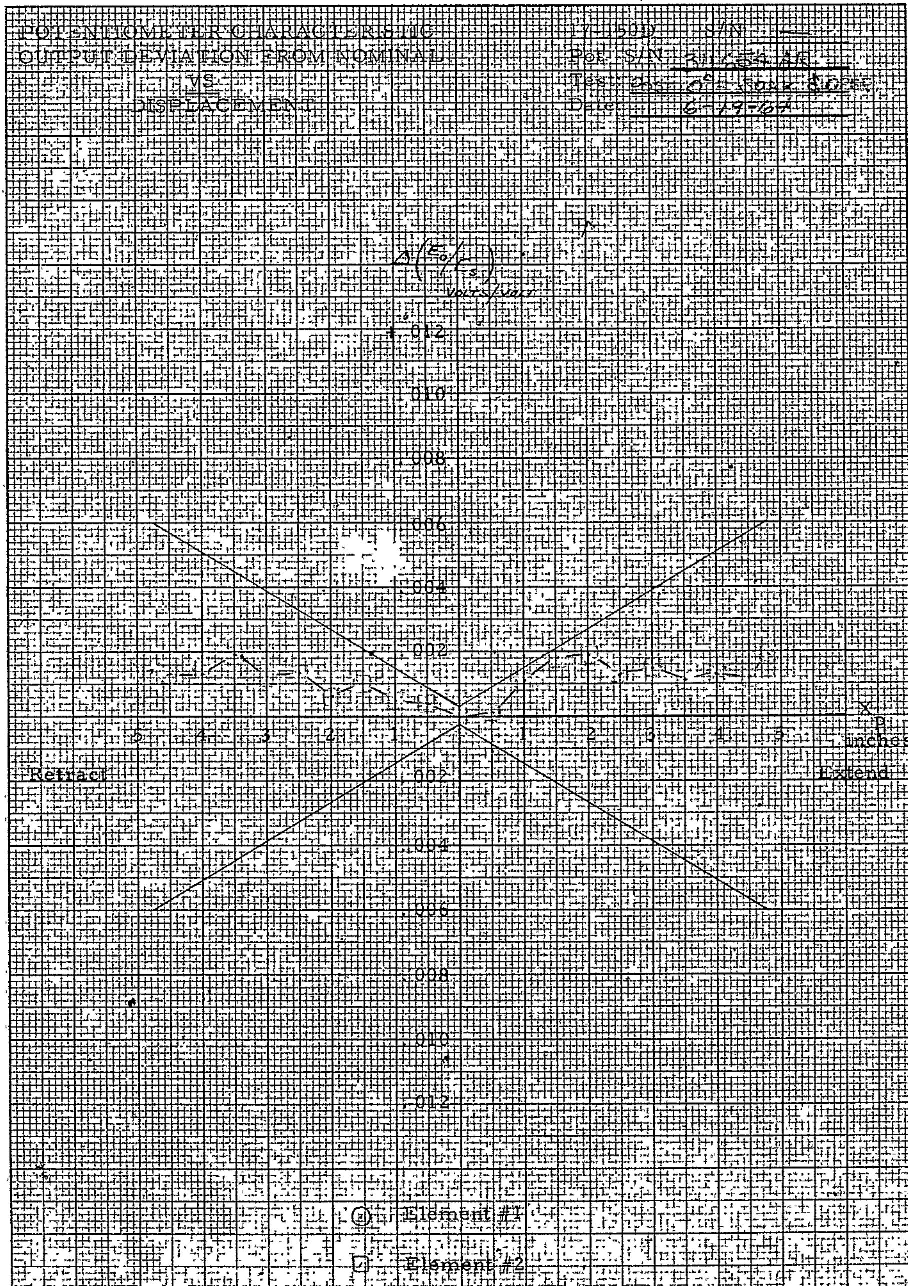
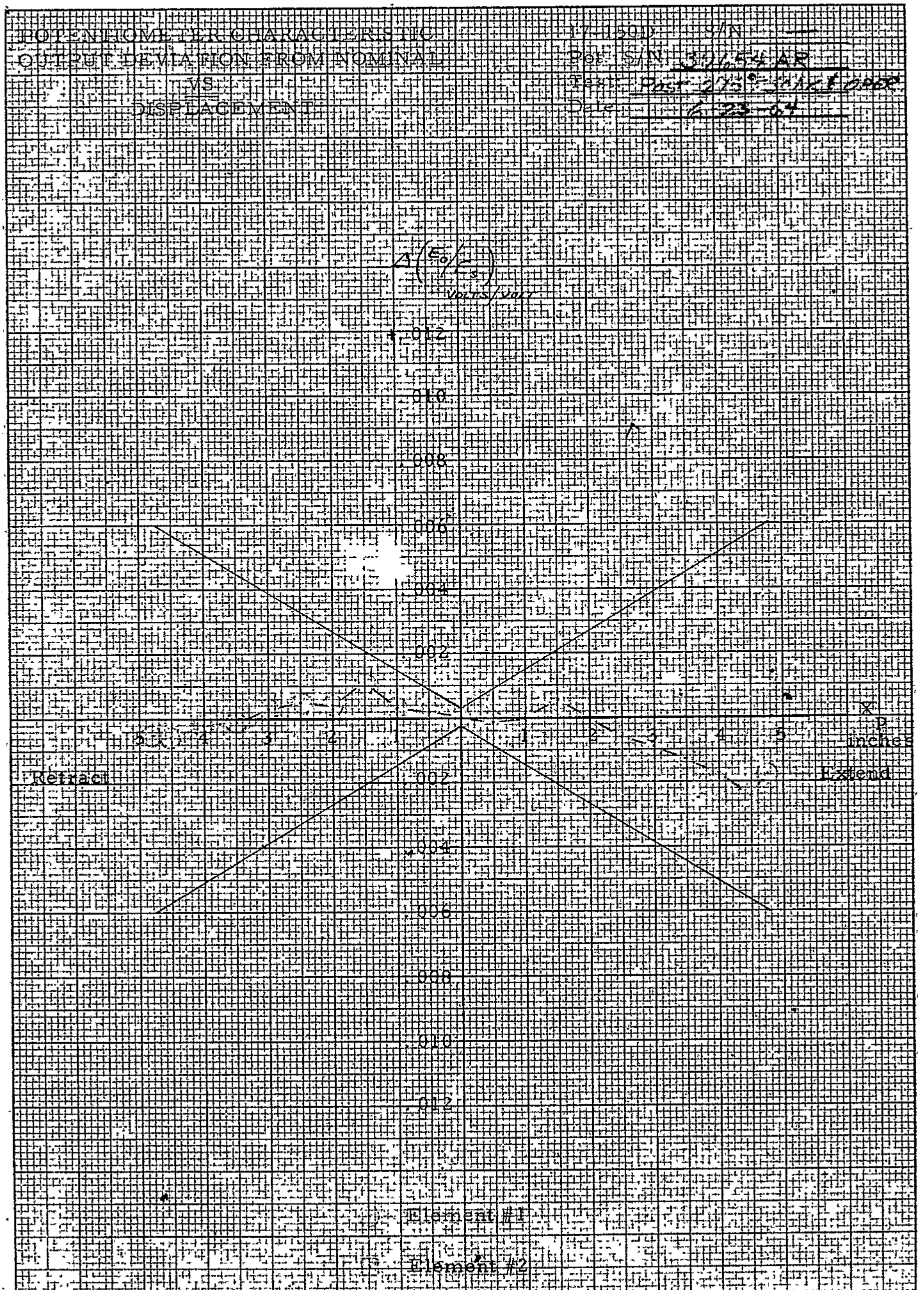

POTENTIOMETER CHARACTERISTIC
OUTPUT DEVIATION FROM NOMINAL
VS
DISPLACEMENT
17-150D S/N
Pot. S/N
Test
Date
.012
.010
.008
.006
.004
.002
5
4
3
2
1
1
2
3
4
5
X
inches
Retract
Extend
.002
.004
.006
.008
.010
.012
Element #1
Element #2

Figure 15



POTENTIOMETER CHARACTERISTIC
OUTPUT DEVIATION FROM NOMINAL
VS
DISPLACEMENT
S/N
Pot S/N
Test
Date
.012
.010
.008
.006
.004
.002
5
4
3
2
1
X
P
inches
Retract
Extend
Element #1
Element #2

Figure 16

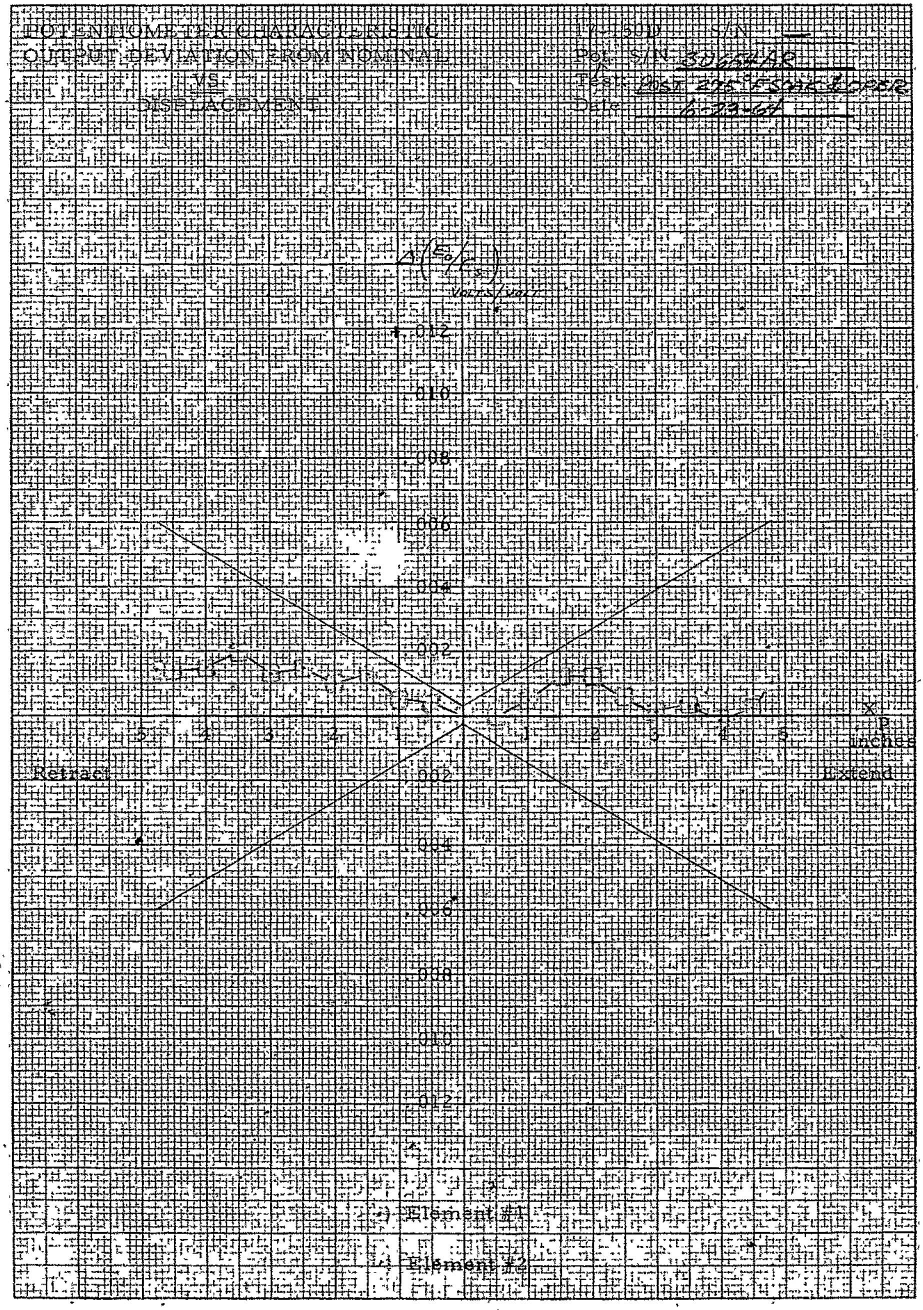
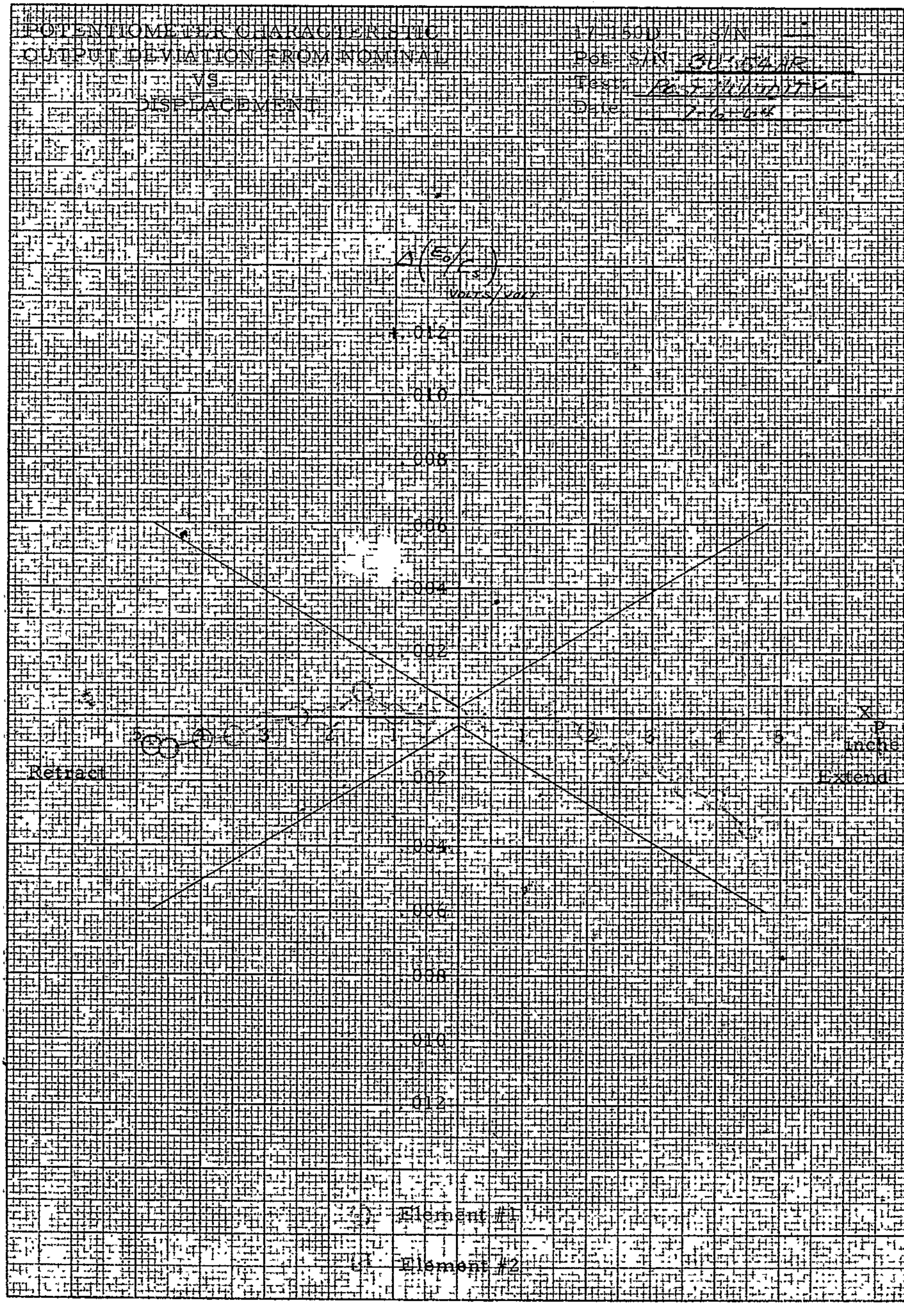

POTENTIOMETER CHARACTERISTIC
OUTPUT DEVIATION FROM NOMINAL
VS
DISPLACEMENT
S/N
Pot. S/N
Test:
Date
Volts/Volt
.012
.010
.008
.006
.004
.002
.002
.004
.006
.008
.010
.012
5
4
3
2
1
1
2
3
4
5
X
P
Inches
Retract
Extend
Element #1
Element #2

Figure 17



POTENTIOMETER CHARACTERISTIC
OUTPUT DEVIATION FROM NOMINAL
VS
DISPLACEMENT
Pot. S/N
Test
Date
$\Delta\left(\frac{E_o}{E_s}\right)$
VOLTS/VOLT
.012
.010
.008
.006
.004
.002
.002
.004
.006
.008
.010
.012
5
4
3
2
1
1
2
3
4
5
X
P
inches
Retract
Extend
Element #1
Element #2

Figure 18

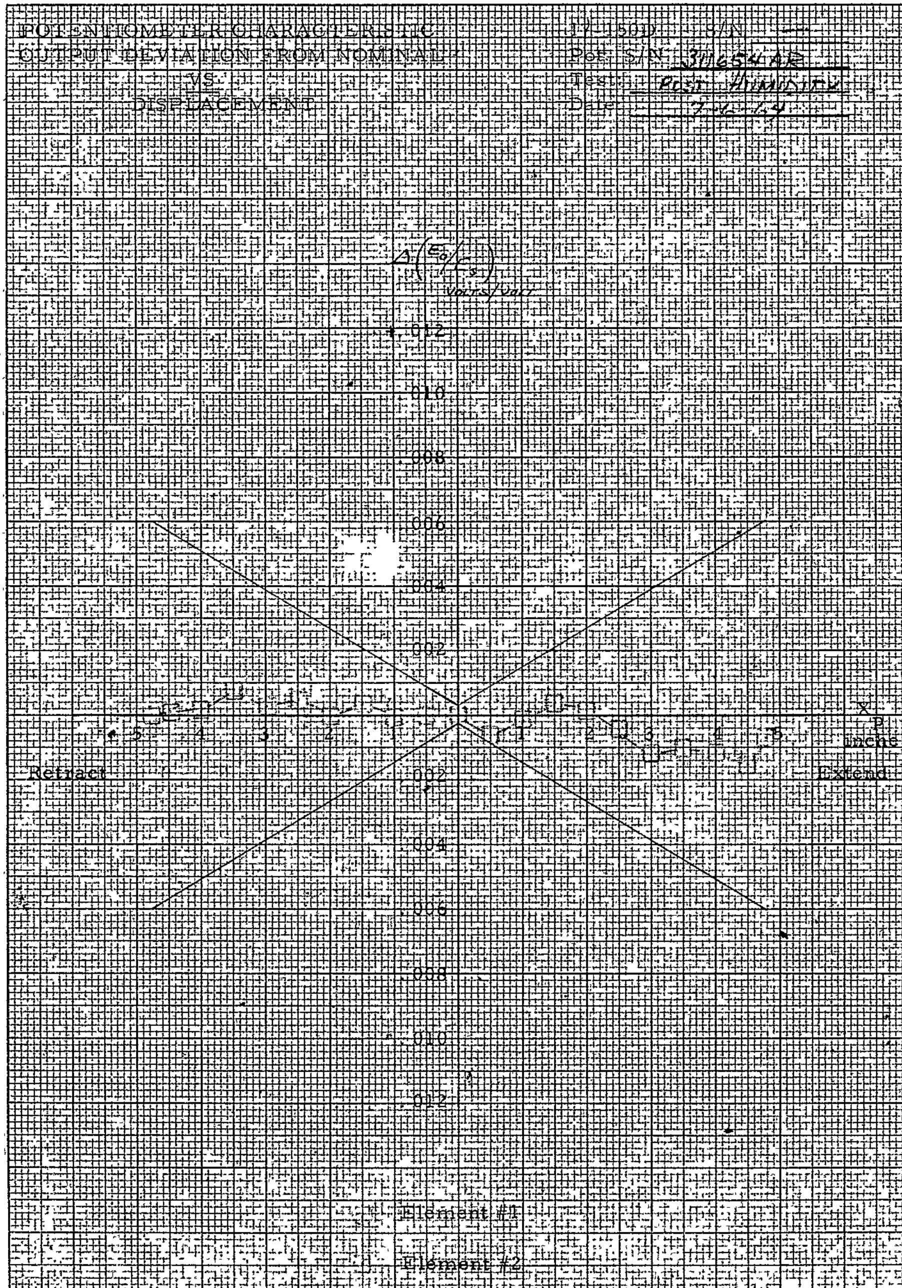

POTENTIOMETER CHARACTERISTIC
OUTPUT DEVIATION FROM NOMINAL
VS
DISPLACEMENT
17-150D S/N —
Pot S/N 3U654AR
Test POST HUMIDITY
Date 7-6-64
Δ(Eo/Es) VOLTS/VOLT
.012
.010
.008
.006
.004
.002
.002
.004
.006
.008
.010
.012
5
4
3
2
1
1
2
3
4
5
X P
inches
Retract
Extend
Element #1
Element #2

Figure 19

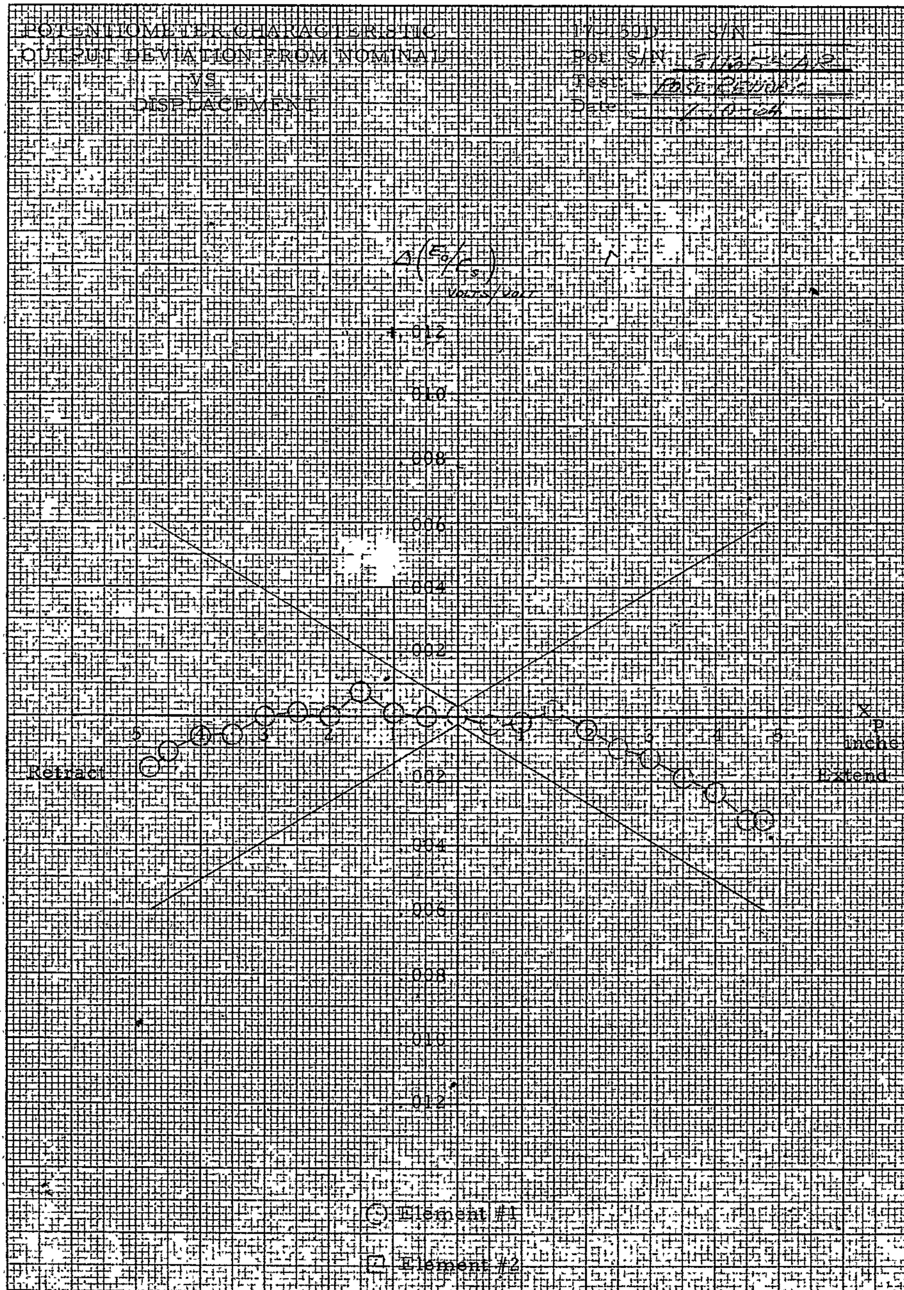

POTENTIOMETER CHARACTERISTIC
OUTPUT DEVIATION FROM NOMINAL
VS
DISPLACEMENT
Pot S/N
Test
Date
.012
.010
.008
.006
.004
.002
.002
.004
.006
.008
.010
.012
5
4
3
2
1
1
2
3
4
5
X
P
inches
Retract
Extend
Element #1
Element #2

Figure 20

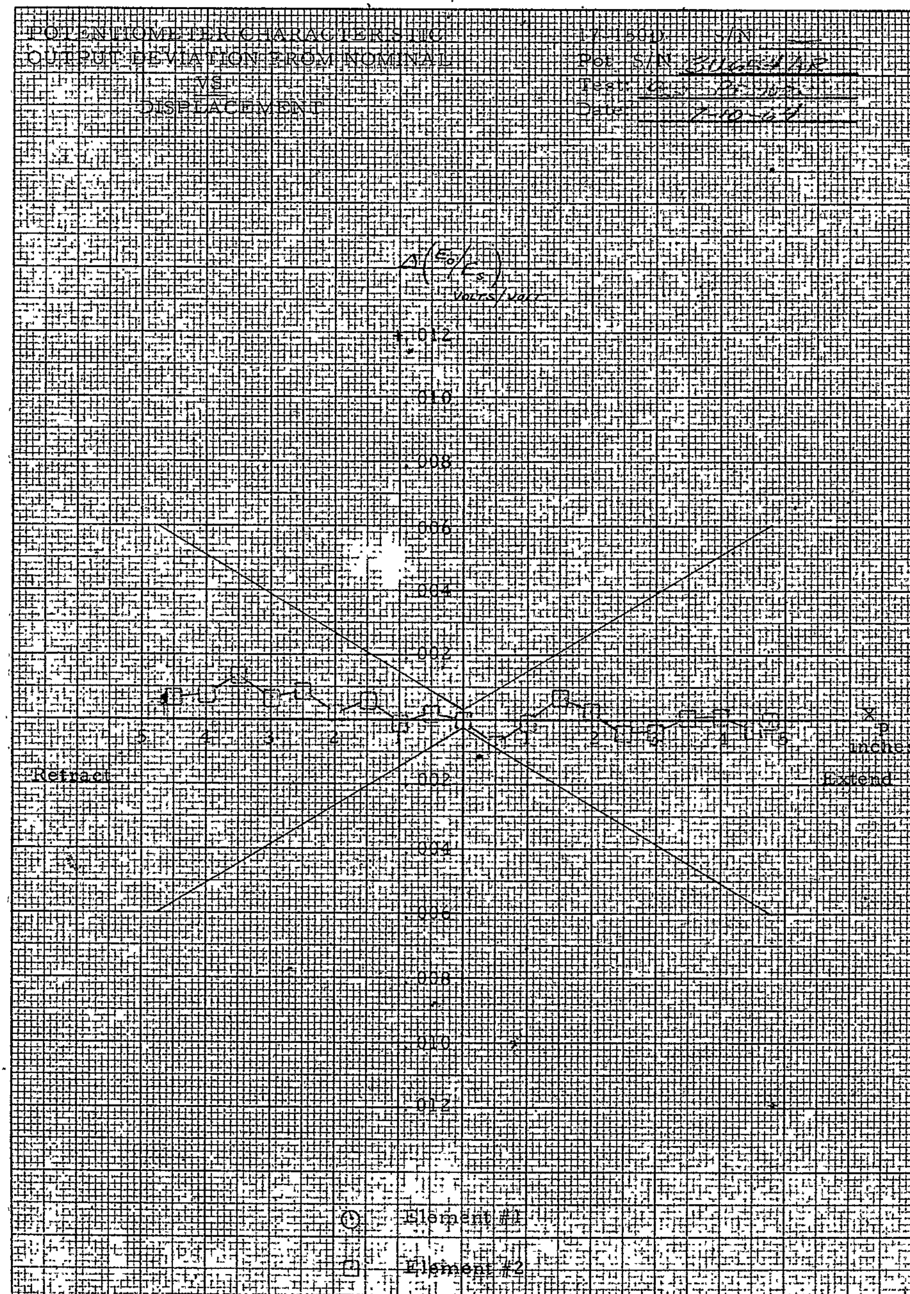

POTENTIOMETER CHARACTERISTIC
OUTPUT DEVIATION FROM NOMINAL
VS
DISPLACEMENT
Pot S/N
Test
Date
.012
.010
.008
.006
.004
.002
5
4
3
2
1
2
3
4
5
inches
Retract
Extend
Element #1
Element #2

Figure 21

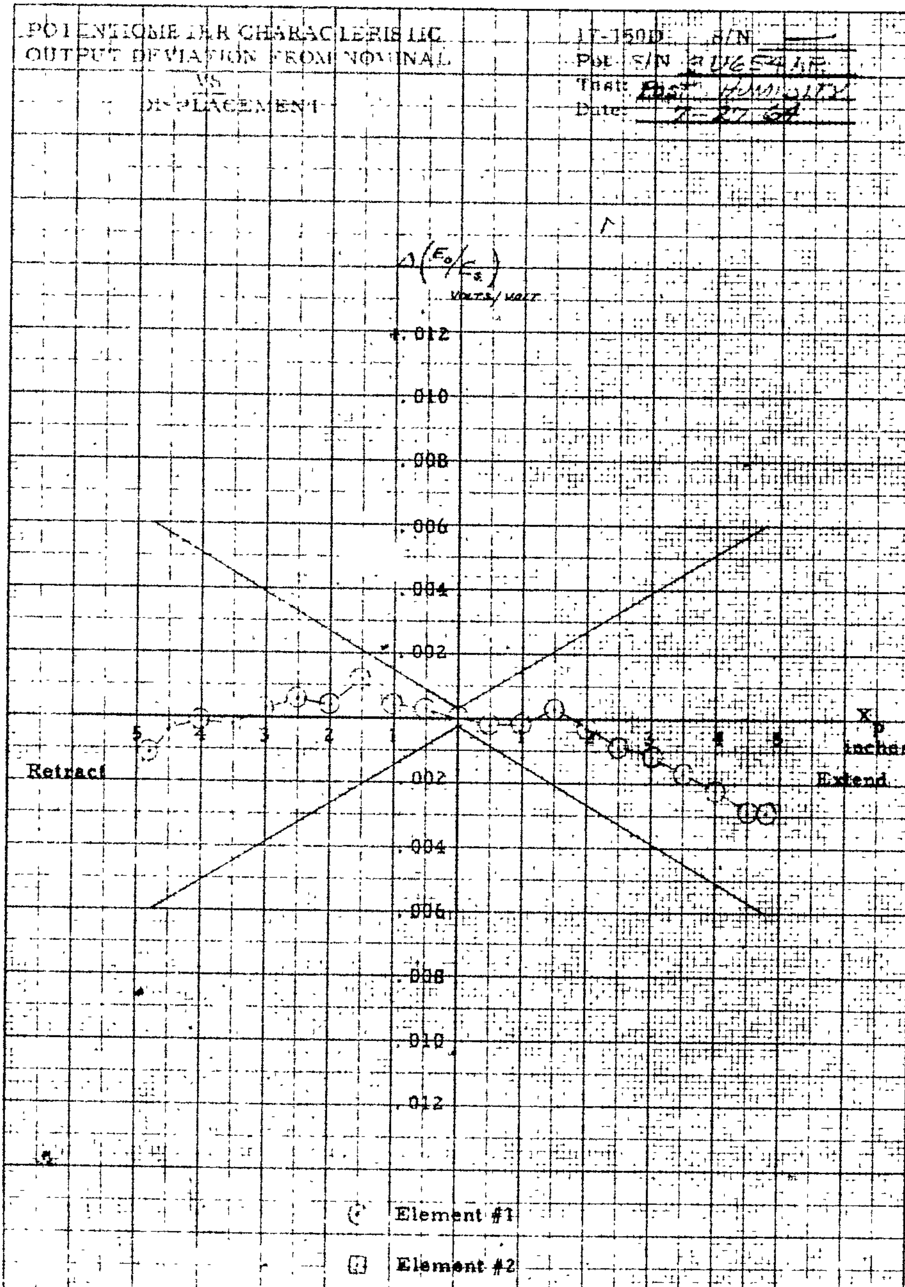

POTENTIOMETER CHARACTERISTIC
OUTPUT DEVIATION FROM NOMINAL
VS
DISPLACEMENT
S/N
Pot S/N
Test:
Date:
VOLTS/VOLT
.012
.010
.008
.006
.004
.002
.002
.004
.006
.008
.010
.012
5
4
3
2
1
1
2
3
4
5
Retract
Extend
inches
Element #1
Element #2

Figure 22

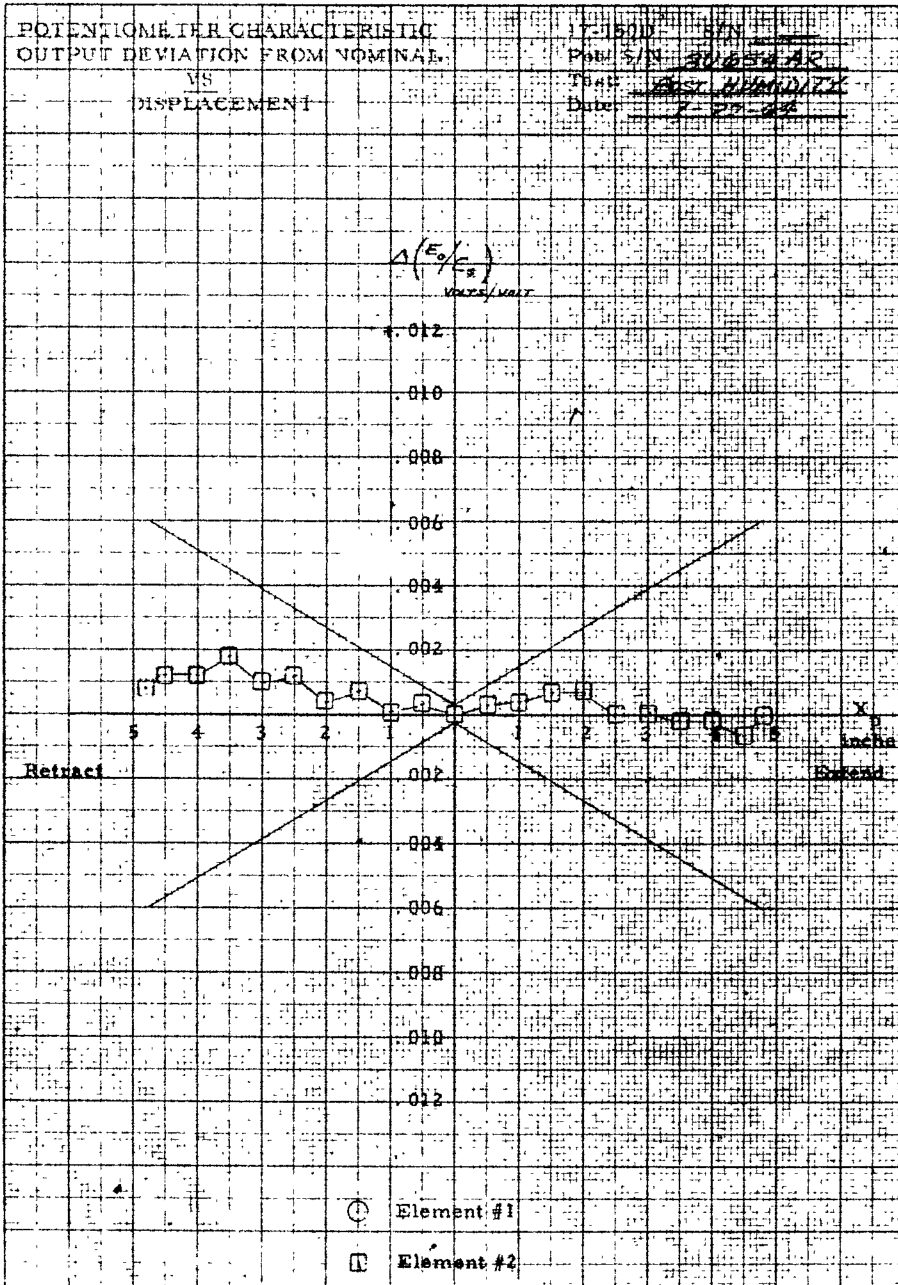
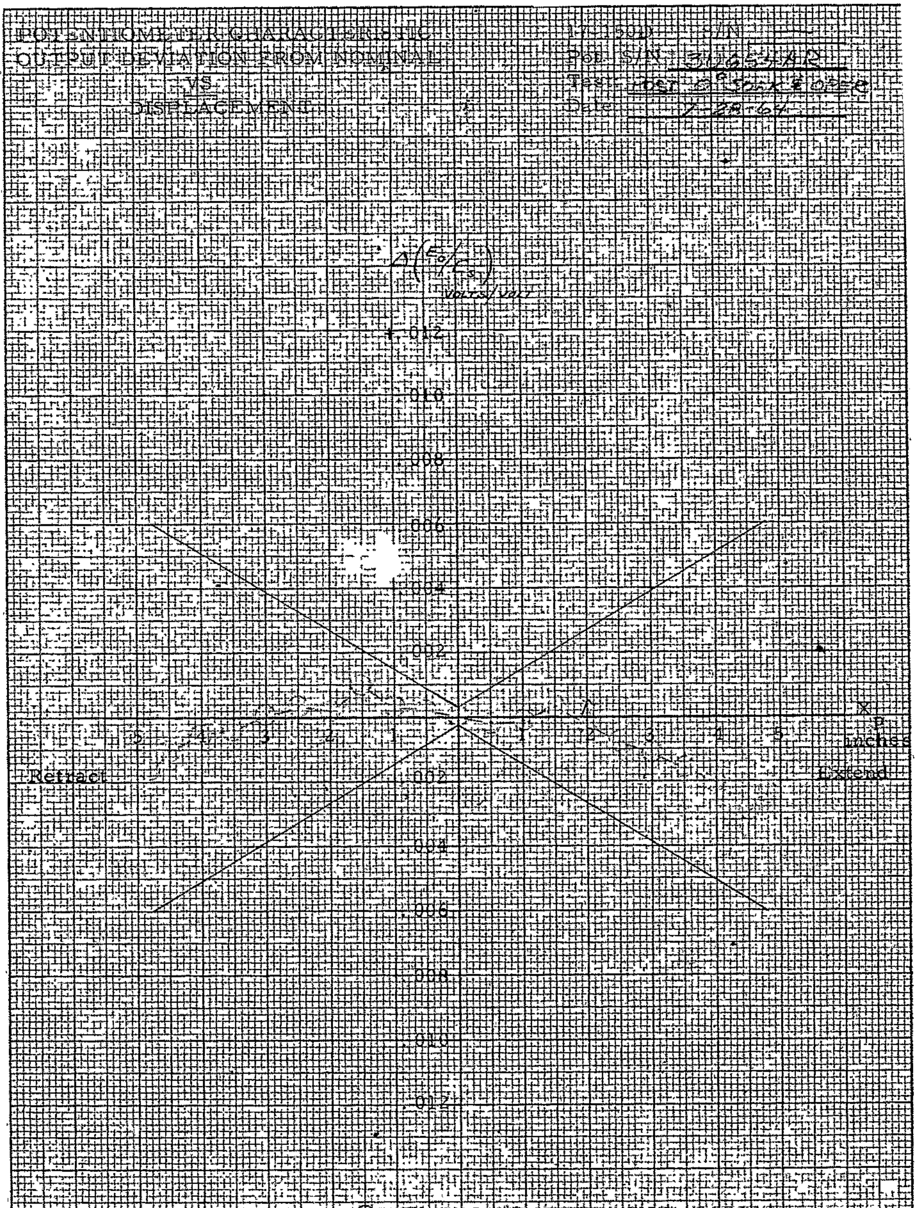

POTENTIOMETER CHARACTERISTIC
OUTPUT DEVIATION FROM NOMINAL
VS
DISPLACEMENT
Pot S/N 30654 AR
Test Post Humidity
Date 7-27-64
$\Delta\left(E_o/E_s\right)$
VOLTS/VOLT
.012
.010
.008
.006
.004
.002
5
4
3
2
1
1
2
3
4
5
X_p
inches
Retract
Extend
Element #1
Element #2

Figure 23



POTENTIOMETER CHARACTERISTIC
OUTPUT DEVIATION FROM NOMINAL
VS
DISPLACEMENT
Pot. S/N
Test
Date
$\Delta(E_o/E_{in})$
Volts/Volt
+.012
.010
.008
.006
.004
.002
.002
.004
.006
.008
.010
.012
5
4
3
2
1
1
2
3
4
5
X_p inches
Retract
Extend
Element #1
Element #2

Figure 24

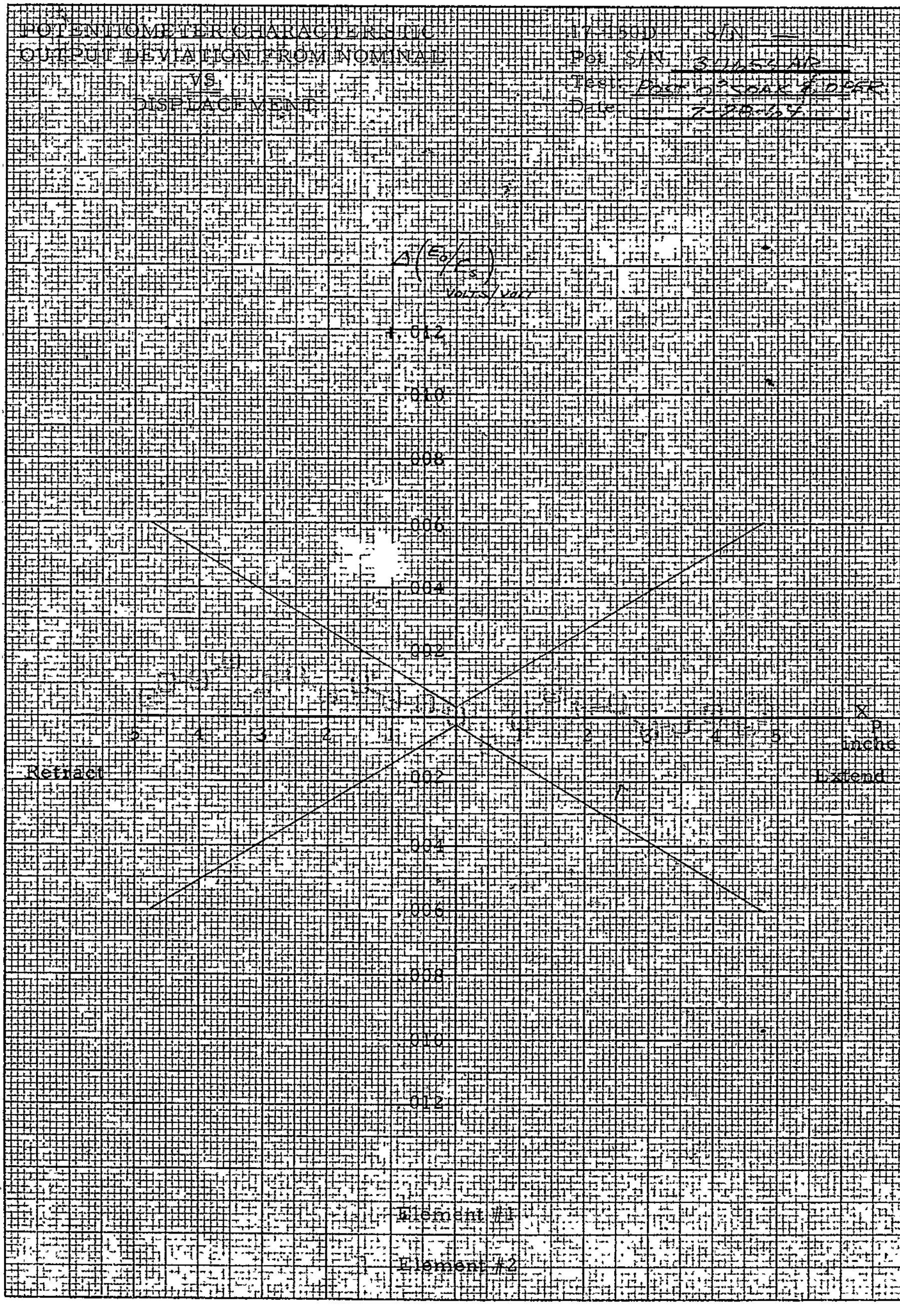

POTENTIOMETER CHARACTERISTIC
OUTPUT DEVIATION FROM NOMINAL
VS
DISPLACEMENT
Pot S/N
Test
Date
Δ(Eo/Es)
VOLTS/VOLT
.012
.010
.008
.006
.004
.002
5
4
3
2
1
1
2
3
4
5
X
P
inches
Retract
Extend
.002
.004
.006
.008
.010
.012
Element #1
Element #2

Figure 25

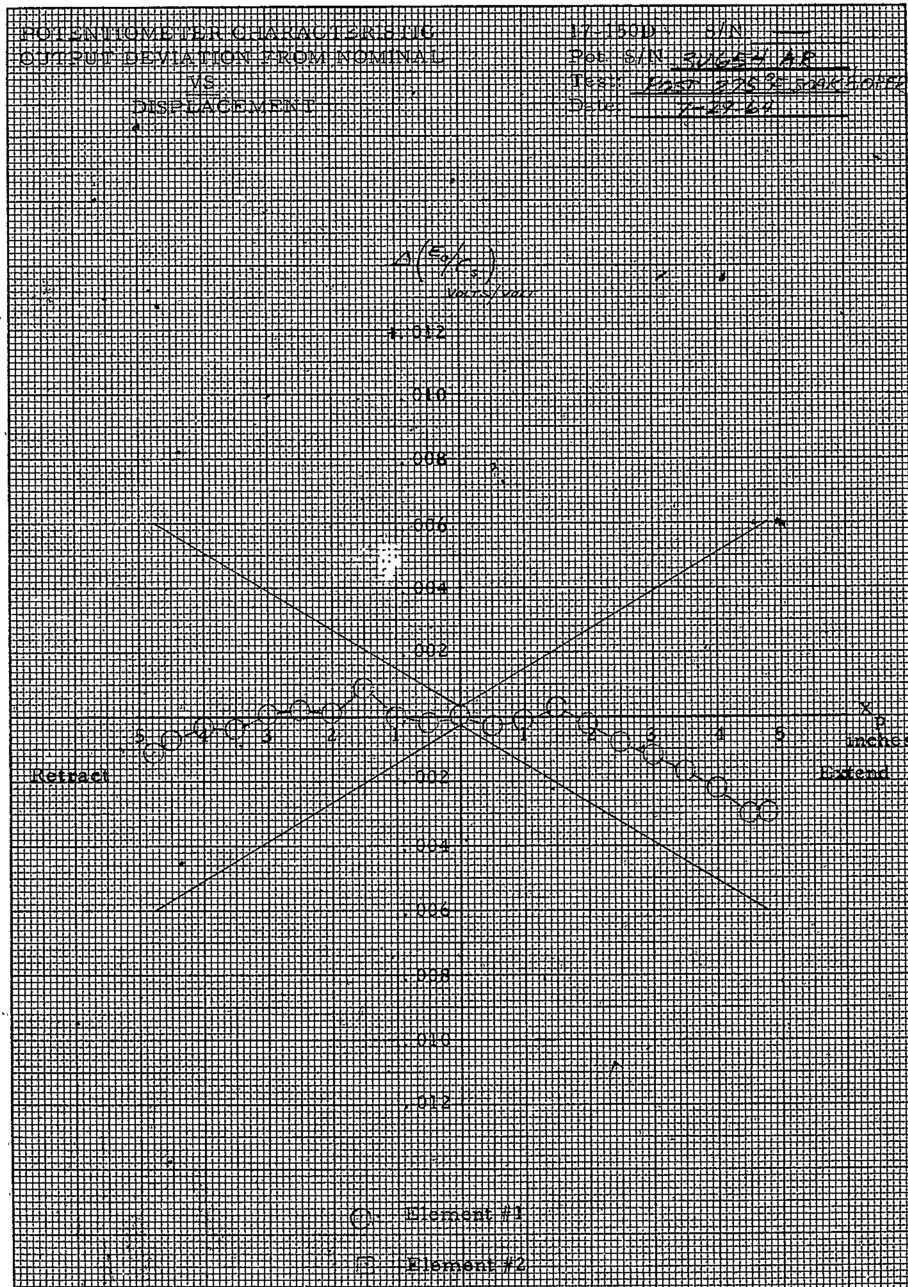
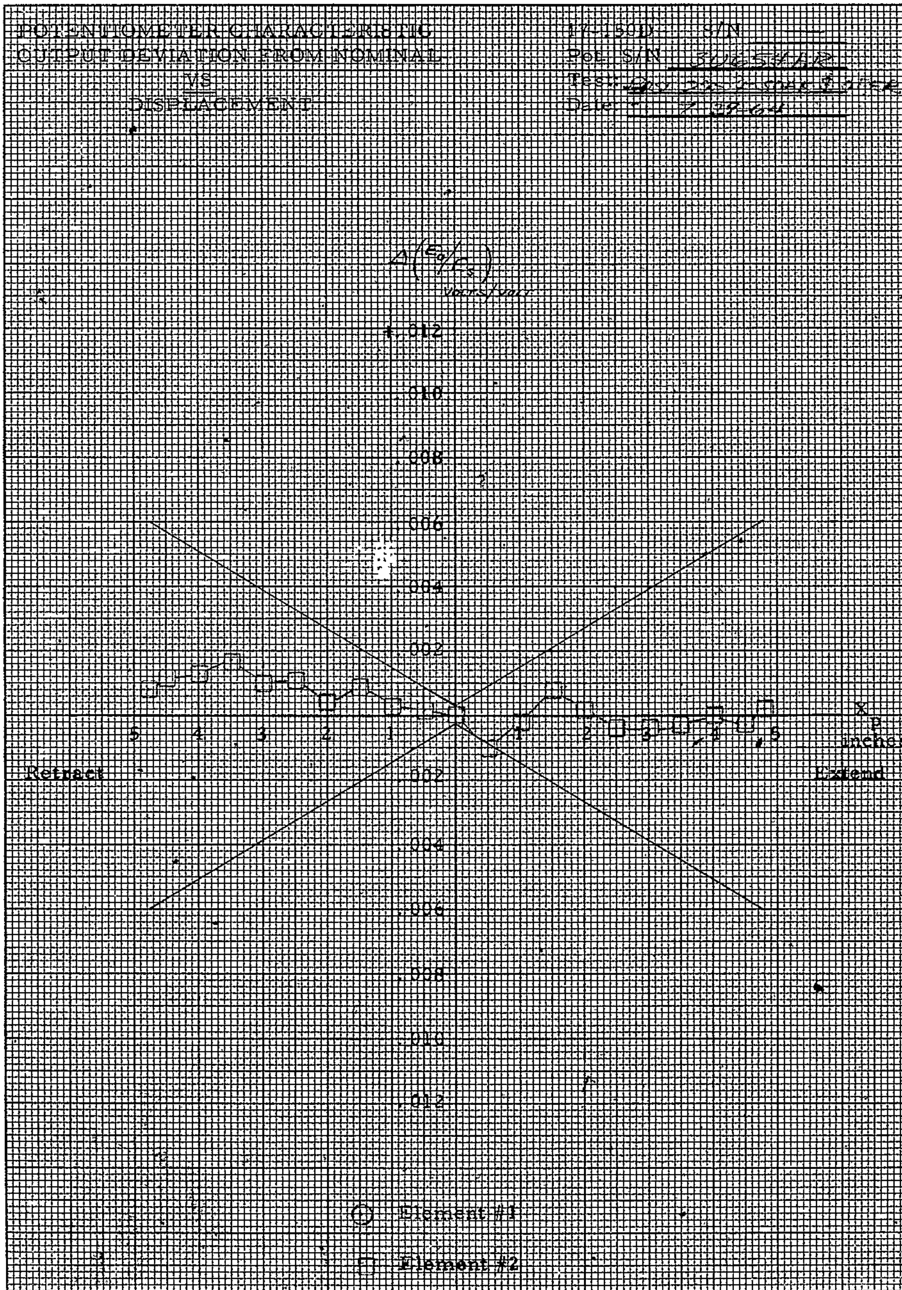

POTENTIOMETER CHARACTERISTIC
OUTPUT DEVIATION FROM NOMINAL
VS
DISPLACEMENT
17-150D S/N —
Pot. S/N 3U654 AR
Test: Post 275°F soak - OFF.
Date: 7-29-64
$\Delta\left(E_o/E_s\right)$
volts/volt
.012
.010
.008
.006
.004
.002
.002
.004
.006
.008
.010
.012
5
4
3
2
1
1
2
3
4
5
X_p
inches
Retract
Extend
Element #1
Element #2

Figure 26



POTENTIOMETER CHARACTERISTIC
OUTPUT DEVIATION FROM NOMINAL
VS
DISPLACEMENT
Pot. S/N
Test:
Date:
$\Delta\left(E_0/E_s\right)$ VOLTS/VOLT
+.012
.010
.008
.006
.004
.002
.002
.004
.006
.008
.010
.012
5
4
3
2
1
1
2
3
4
5
X P inches
Retract
Extend
Element #1
Element #2